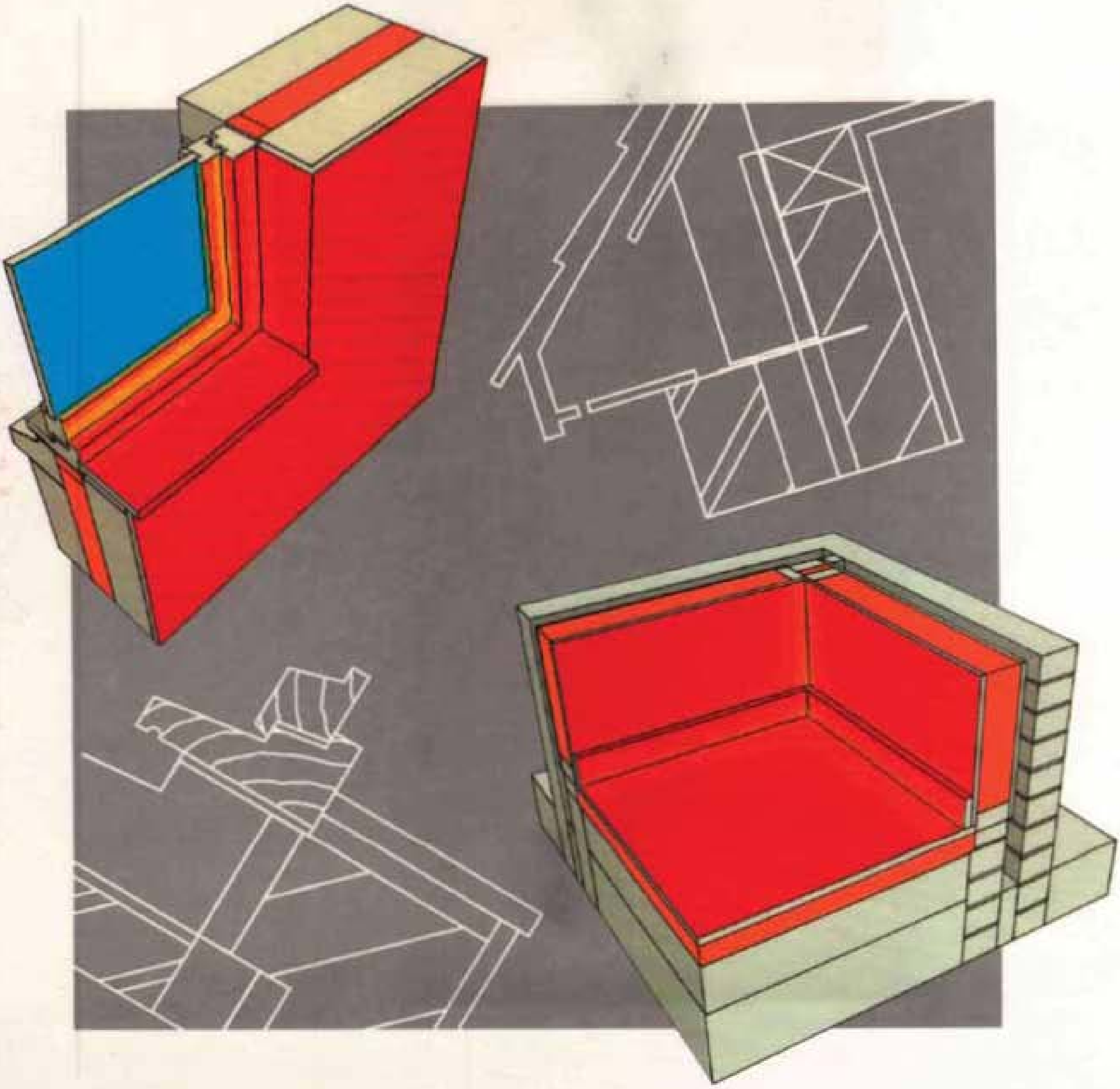
Department of the
ENVIRONMENT

GOOD PRACTICE GUIDE 174

Minimising thermal bridging in new dwellings

A detailed guide for architects and building designers



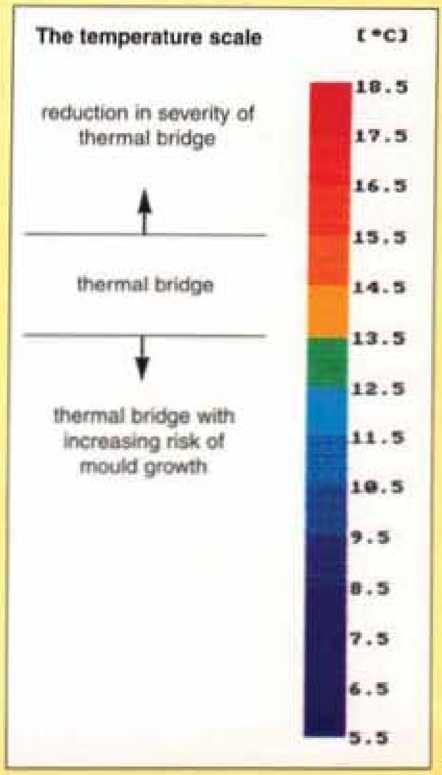
BEST PRACTICE PROGRAMME

ENERGY EFFICIENCY

BEST PRACTICE
PROGRAMME

GOOD PRACTICE GUIDE 174

Minimising thermal bridging in new dwellings



Contents

Introduction

This Guide is aimed at architects and building designers. It will also be of interest to specifiers and builders. The document examines a wide range of details in new build, domestic constructions where thermal bridging is a potential problem.

Complementary information can be obtained from the *'Thermal insulation: avoiding risks'* [1] document available from HMSO.

Thermal bridges are areas of the fabric where, because of the materials used or the geometry of the construction, heat flows are higher than through the rest of the building. This directly results in a higher energy requirement for the building but, more importantly, the higher heat flow through the thermal bridge leads to lower internal surface temperatures and an increased risk of mould growth. This can have a much greater impact on energy consumption, as attempts are made to cure the mould by raising internal temperatures or increasing ventilation rates. Moulds are a major source of distress for householders and can cause respiratory and other allergies in sensitive people.

Minimising thermal bridges

The Guide shows how, by careful detailing, thermal bridges can be minimised. A colour scale is used to represent surface temperatures. This highlights in a clear way the extent and severity of the thermal bridges.

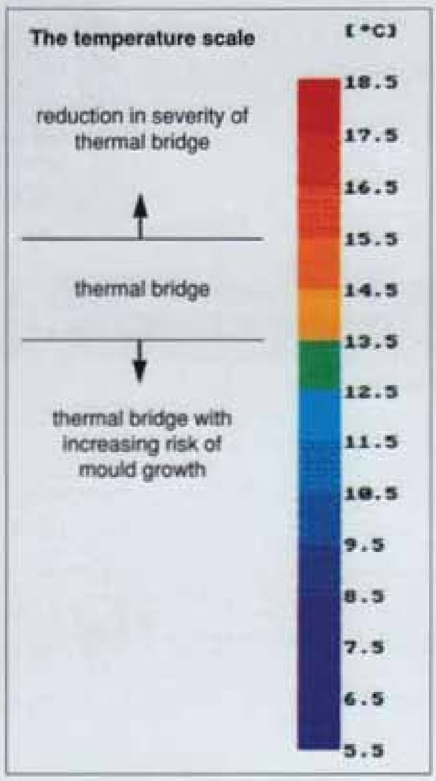
Where surface temperatures are 13.5°C or less, coloured green and blue on the temperature scale, there is a risk of mould growth given the humidities normally occurring in UK housing. Where surface temperatures are between 13.5 and 15.5°C, coloured yellow and orange on the temperature scale, a thermal bridge still exists, but, given the temperatures and humidities likely in new build housing complying with the Building Regulations 1990, mould growth is unlikely. A reduction in the severity of the thermal bridge is seen at temperatures above 15.5°C, coloured red on the temperature scale.

The Guide is divided into 14 Chapters, each of which illustrate a different form of construction. A brief introduction to each chapter describes the form of construction used in the analysis.

The junctions in each chapter are given a boxed code letter, eg $\boxed{A}$. The same code letters are used subsequently in the summary table which concludes each chapter. The summary table illustrates the range of junctions investigated and contains advice on:

- minimum recommendations to reduce the risk of mould growth occurring
- recommendations for Best Practice, where appropriate.

[1] **BRE Report BR 262, 1994**
'Thermal insulation: avoiding risks'.



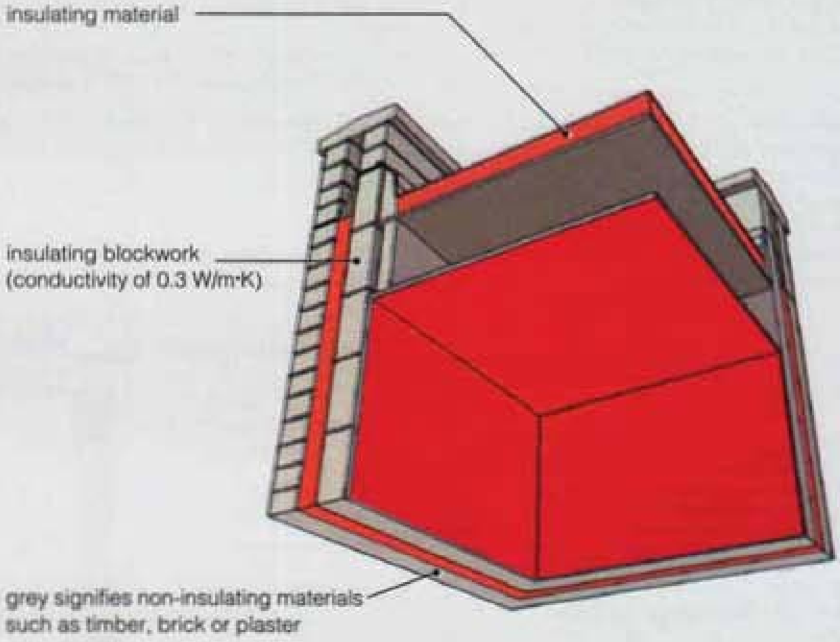
Assumptions

The surface temperatures in the Guide have been calculated using the TRISCO computer program based on finite element analysis. The calculations use an inside temperature of 18°C, typical of the average in a reasonably well heated living room, and an outside temperature of 0°C, typical of cold winter conditions in the UK. The calculations were carried out assuming constant internal and external temperatures. This may give a slightly optimistic assessment of the performance of some constructions, especially those with massive concrete or masonry elements, under the fluctuating temperatures found in housing.

All the constructions used in the Guide comply with the requirements of the 1994 revision to Approved Document L of the Building Regulations for England and Wales. In particular, the bridging effects of mortar joints and timber members have been taken into account when calculating the U-values. In general, the wall and floor constructions achieve a U-value of 0.45 W/m²K or better. Roof constructions achieve a U-value of 0.25 W/m²K or better. All windows are double glazed with a U-value of 3.0 W/m²K for the glazed areas.

Where the term 'insulating blockwork' is used in the Guide, it refers to blocks with a thermal conductivity of 0.3 W/m·K or less. This would include lightweight aggregate blocks with a density of about 1000 kg/m³ or less and all aircrete blocks.

Key to three-dimensional illustrations



DISCLAIMER

The diagrams and details in this document are for illustrative purposes only. In many of the diagrams dpcs, dpms and vapour barriers have been omitted to reduce complexity.

Summary pages at the end of each chapter should not be regarded as 'working drawings' but simply recommendations on how to reduce thermal bridges.

Pitched roofs

The ease with which rolls of mineral wool quilt can be added between ceiling joists has meant that this method of insulating a pitched roof has been a familiar sight for twenty years.

The illustrations in this chapter show the insulation laid in two layers – 100 mm between the joists and 60 mm across the joists. This achieves a U-value of 0.25 W/m^{2}K, after taking into account the thermal bridging effect of the timber joists.

It is also possible to achieve a U-value of 0.25 W/m^{2}K by laying a single layer of mineral wool, 220 mm thick, between the joists. With this method of insulation the heat loss through the ceiling joists is higher than through the insulation, but is not sufficiently serious to present a mould growth risk.

The most potentially serious thermal bridges in a pitched roof are not through the ceiling joists, but at the roof perimeter.

The thermal bridges at the eaves and gable wall junctions can be sufficiently serious for there to be a risk of mould growth. The illustration below shows an eaves detail where the insulation has not been firmly pushed down onto the plasterboard ceiling. Cold air from the eaves ventilation chills the ceiling, resulting in a high risk of mould growth.

The results on the following pages illustrate the advantages of:

- carrying the loft insulation over the wall plate at the eaves, especially where the walls have cavity insulation
- butting the loft insulation up against the gable wall to avoid an uninsulated gap between the last ceiling joist and the wall.

A CAVITY INSULATED WALL – EAVES DETAIL

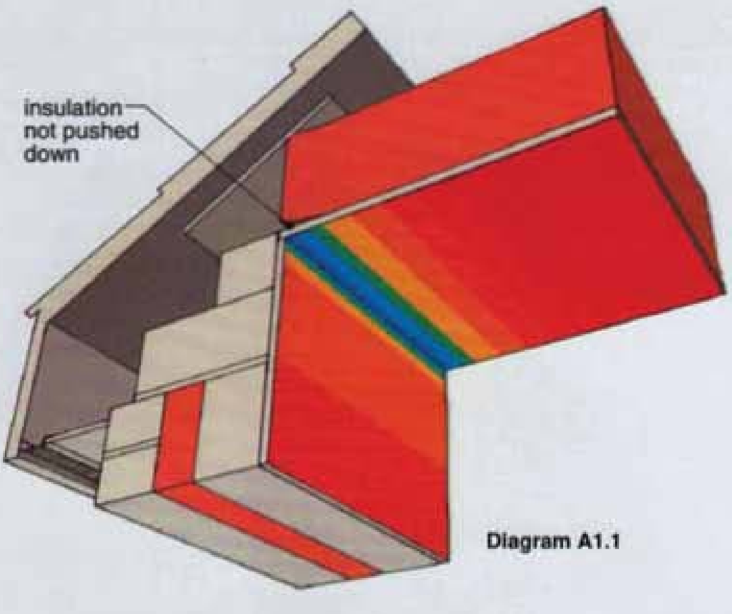


Diagram A1.1

MAJOR RISK OF MOULD

This is very common detail. Diagram **A1.1** shows the danger of stopping the loft insulation at the wall plate. If the insulation is not firmly pushed down onto the plasterboard, cold air from the eaves ventilation can chill the ceiling and result in a major risk of mould.

A CAVITY INSULATED WALL - EAVES DETAIL (continued)

SLIGHT RISK OF MOULD

Where the insulation is not taken over the wall plate a slight risk of mould exists, as shown in Diagram **A1.2**.

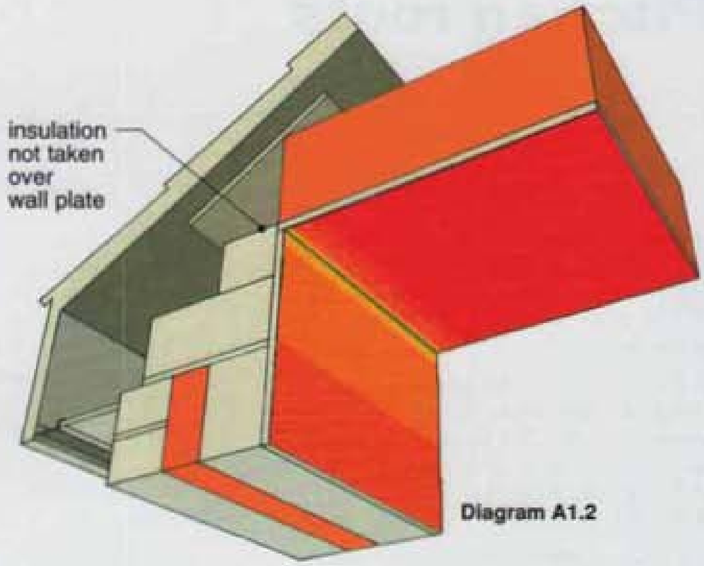


Diagram A1.2

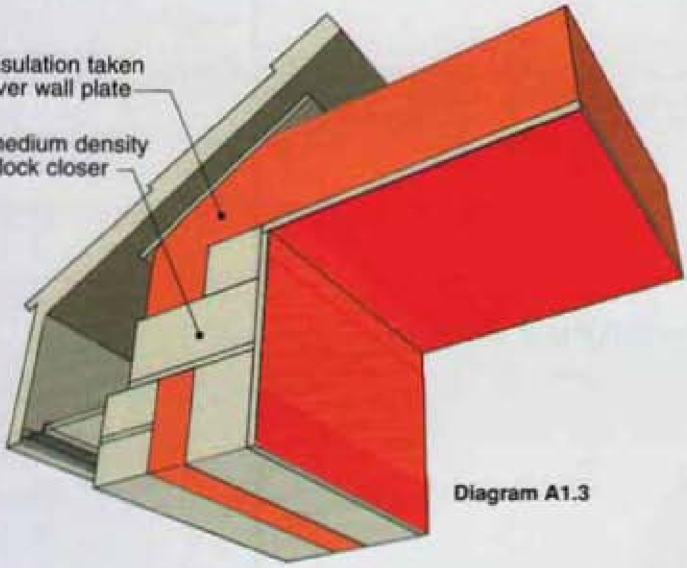


Diagram A1.3

MINOR THERMAL BRIDGE

Loft insulation should always be carried over the wall plate, as shown in Diagram **A1.3**.

To ensure that insulation is correctly positioned around the wall plate, with no gaps, short lengths of insulation quilt should be placed in position immediately before the ventilation tray and sarking felt are fixed. The main loft insulation can then be butted up to this 'wall plate' insulation once the ceiling is in place.

BEST PRACTICE

Although the detail in Diagram **A1.3** avoids mould growth problems, the medium density block used to close the cavity breaks the continuity between the roof and wall insulation. Omitting the block cavity closer, as in Diagram **A1.4** gives the best results.

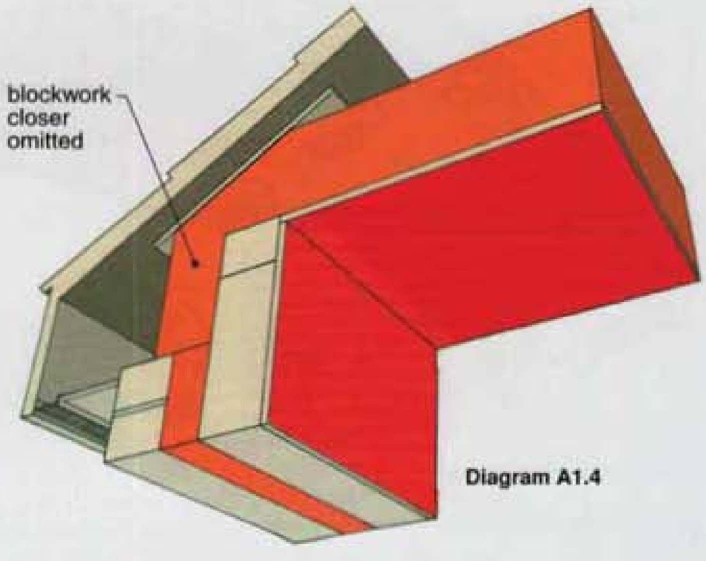


Diagram A1.4

B CAVITY INSULATED WALL – DEEP EAVES DETAIL

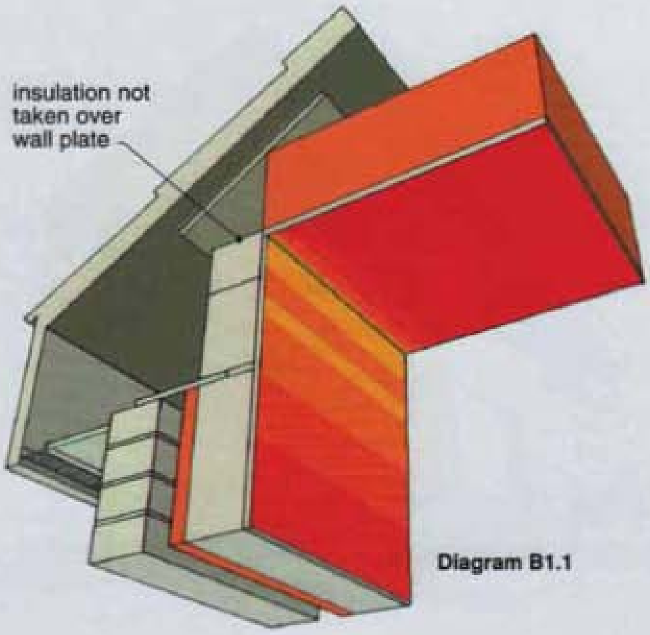


Diagram B1.1

SLIGHT RISK OF MOULD

Diagram **B1.1** shows the risk of mould growth if the loft insulation is not taken over the wall plate. In addition, the partial cavity fill is omitted above the cavity closer, resulting in a clear thermal bridge.

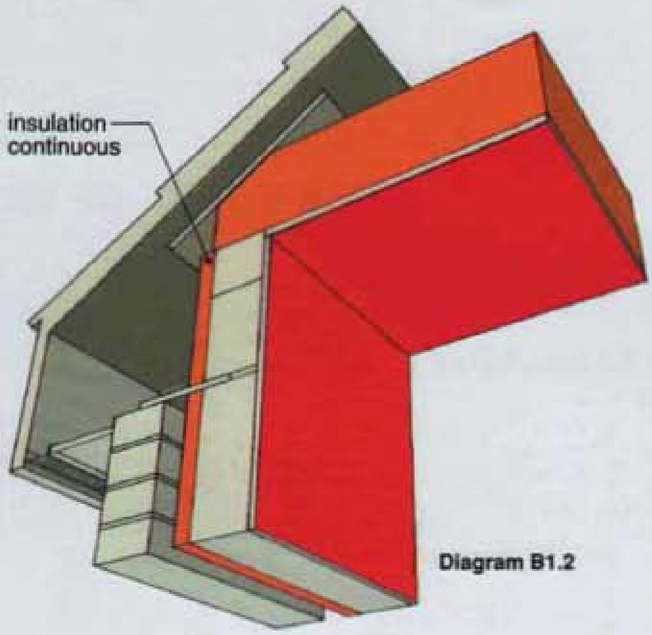


Diagram B1.2

NO THERMAL BRIDGE

Diagram **B1.2** shows the elimination of the thermal bridge by ensuring continuity of insulation. This is dependent on the loft insulation being pushed over the wall plate from inside the roof space. Care should be taken not to dislodge the partial fill board.

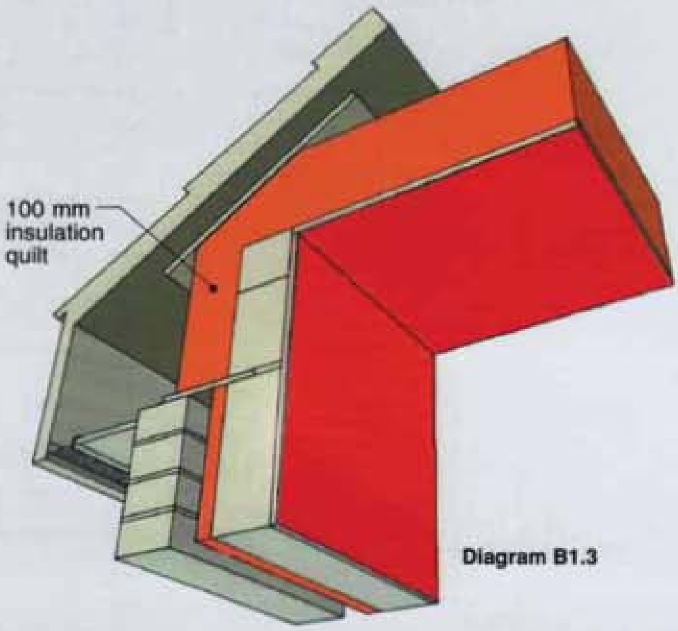


Diagram B1.3

BEST PRACTICE

A more robust solution is to place 100 mm insulating quilt over the wall plate, as shown in Diagram **B1.3**. This should be placed immediately before the ventilator tray and sarking felt are fixed to avoid damage by wind or rain. The main loft insulation can then be butted up to this 'wall plate' insulation.

C INTERNALLY INSULATED WALL – EAVES DETAIL

BEST PRACTICE

Taking the loft insulation over the wall plate, as in Diagram **C1.1**, provides good continuity between the wall and roof insulation.

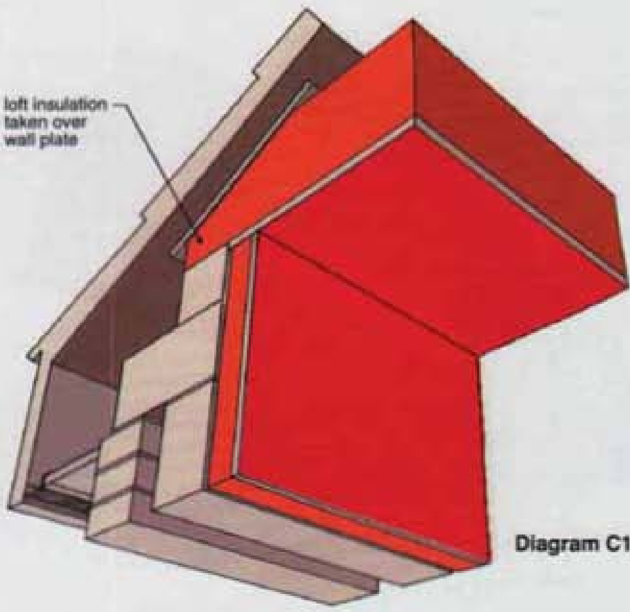
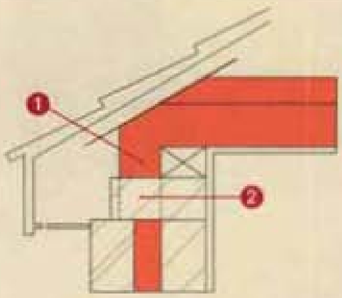
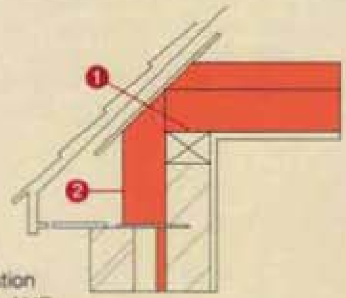
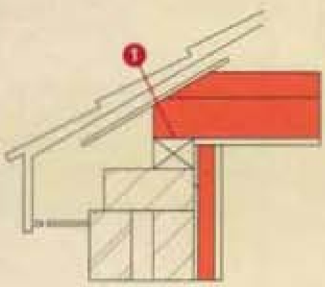


Diagram C1.1

SUMMARY OF RECOMMENDATIONS

Wall insulation	Pitched roofs	
Cavity insulated wall	**A**  **Best Practice** 1 Take loft insulation over the wall plate 2 Omit blockwork closer and link loft and cavity insulation.	**B**  **Best Practice** 1 Take loft insulation over wall plate, AND 2 Continue the loft insulation down from the wall plate to the cavity closer. This insulation should be positioned immediately before the ventilation tray and sarking felt are laid.
Internally insulated wall **Note:** Internal insulation should include a vapour check on the warm side of the insulation	**C**  **Best Practice** 1 Take the loft insulation over the top of the wall plate.	

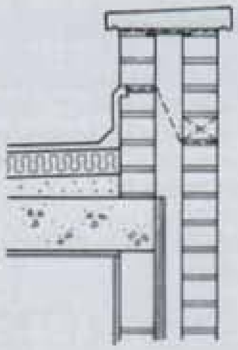
Flat roofs

Introduction
This chapter includes examples of timber and concrete flat roofs. Both types of construction are shown in combination with wall insulation located either in the cavity or as an internal dry lining. Each wall/roof combination has been investigated with a parapet wall and oversailing eaves.

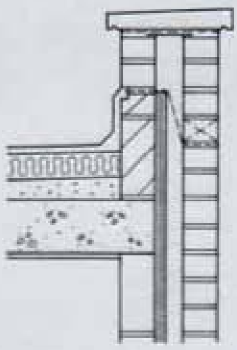
All the flat roofs have the roof insulation above the deck and have a U-value of about 0.32 W/m^{2}K. The weatherproof membrane is shown above the insulation, but the details are equally applicable to inverted warm deck roofs, in which the weatherproof membrane is placed below the insulation. Cold deck timber roofs have not been investigated as this type of construction is considered a poor option in the temperate, humid climate of the UK, where sufficient ventilation may not be achieved in sheltered locations or in windless conditions, even when the roof is correctly designed.

There are potentially serious thermal bridge paths where gaps are left between the wall and roof insulation. The illustrations below contrast the performance of two parapet details.

On the left, stopping the cavity insulation at the top edge of the concrete slab leaves a serious thermal bridge with a slight risk of mould growth. On the right the cavity insulation is taken up to the top of the cavity tray and insulating blockwork is used between the two insulation layers.

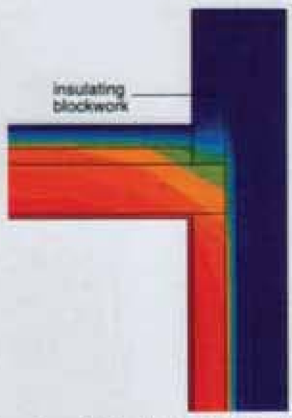


Construction detail



Construction detail

Detail with thermal bridge through edge of slab



Wall and roof insulation 'overlap' to avoid thermal bridge

A CAVITY INSULATED PARAPET WALL - CONCRETE FLAT ROOF

SLIGHT RISK OF MOULD

Where the cavity insulation is not taken up to lap the roof insulation, as in Diagram **A2.1**, a thermal bridge exists, with a risk of mould growth in the corner.

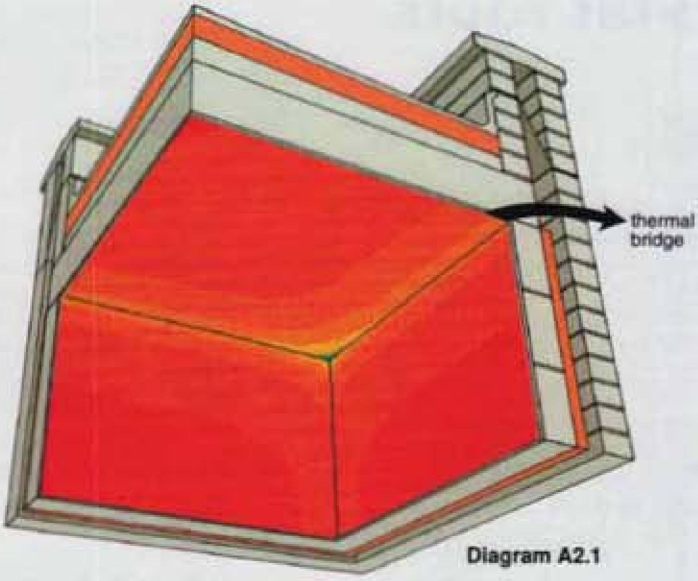


Diagram A2.1

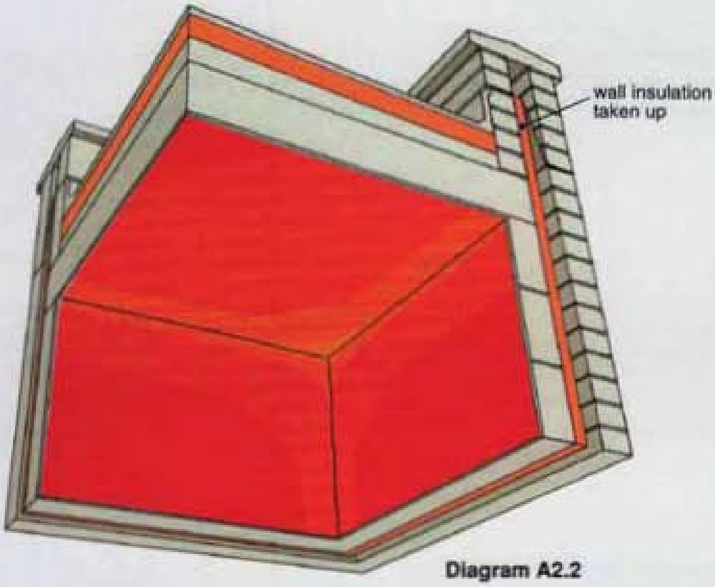


Diagram A2.2

MINOR THERMAL BRIDGE

Taking the cavity insulation up to at least the level of the roof insulation, as in Diagram **A2.2**, raises temperatures sufficiently for there to be little risk of mould growth. However, the brickwork above the concrete slab is still a weak link.

BEST PRACTICE

Using an insulating block above the concrete slab, as in Diagram **A2.3**, minimises the thermal bridge, raising surface temperatures further.

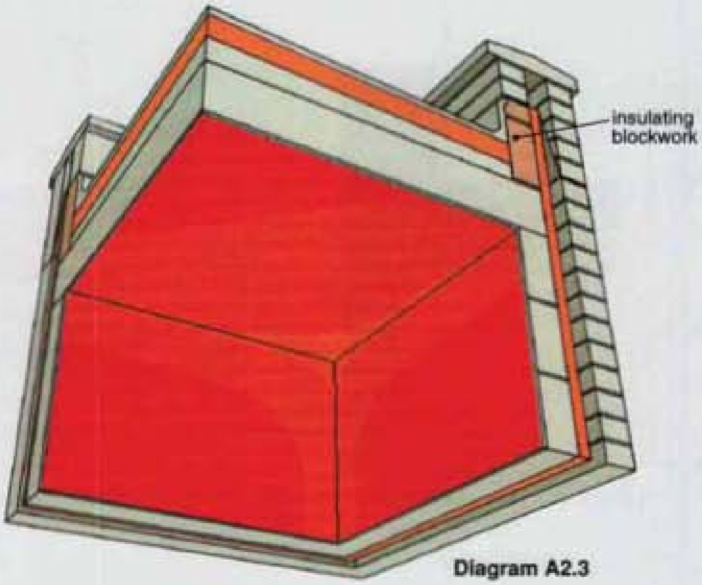


Diagram A2.3

B CAVITY INSULATED WALL – CONCRETE FLAT ROOF

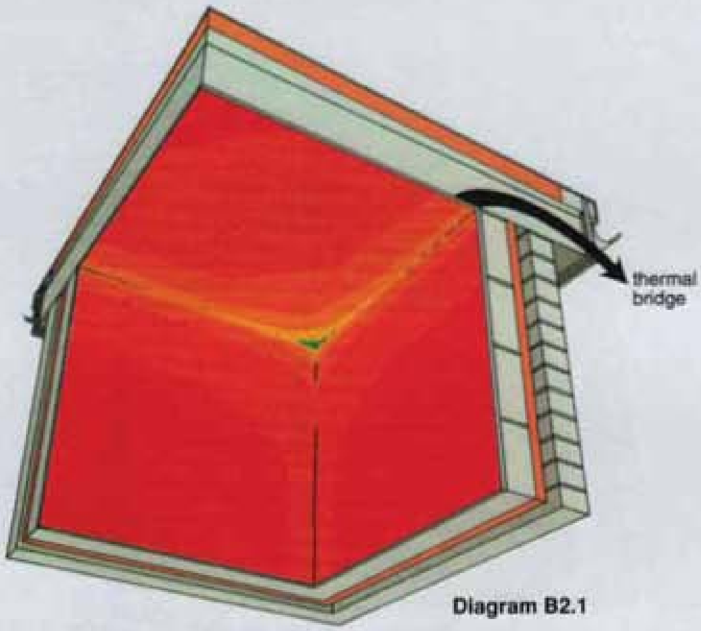


Diagram B2.1

SLIGHT RISK OF MOULD

As detailed in Diagram **B2.1**, the concrete roof slab creates a classic thermal bridge, with a risk of mould growth in the corner.

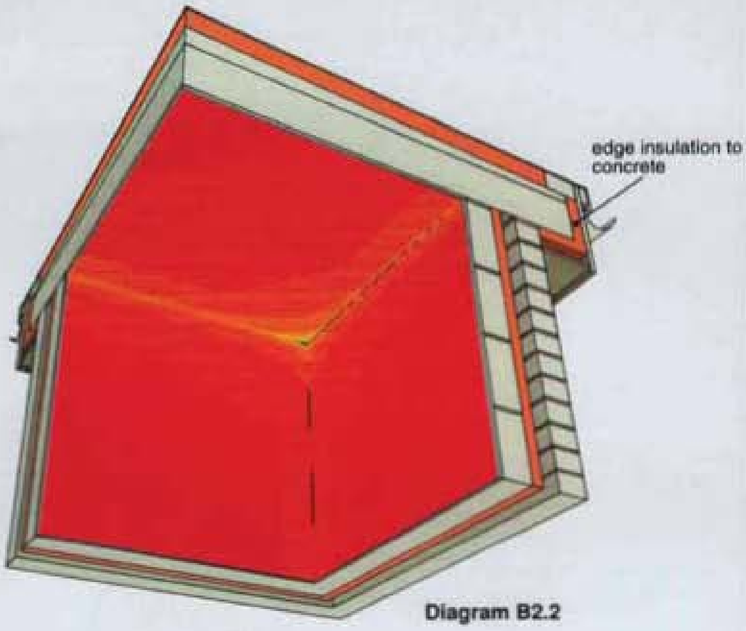


Diagram B2.2

SLIGHT RISK OF MOULD

Covering the exposed edges of the slab with insulation, as in Diagram **B2.2,** has surprisingly little effect. This is largely because the thermal bridge through the outer leaf of the cavity wall still exists.

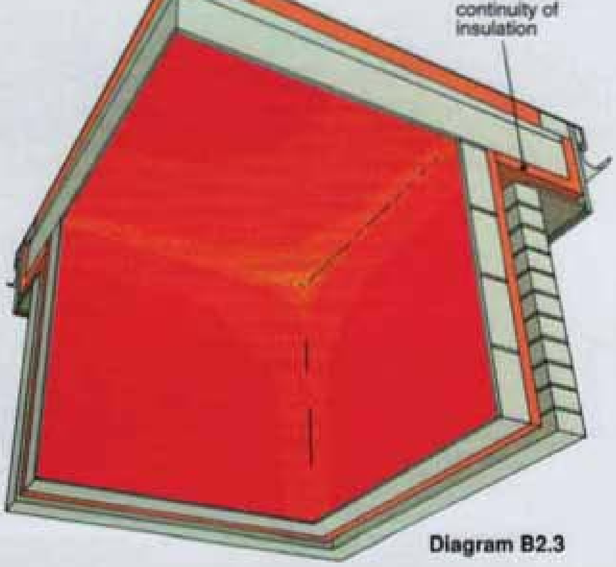


Diagram B2.3

BEST PRACTICE

Providing full continuity of insulation, as in Diagram **B2.3**, gives the best results. However, surface temperatures in the corner are still relatively low, affected by the mass of cold concrete that projects beyond the structural inner leaf.

C CAVITY INSULATED PARAPET WALL – TIMBER FLAT ROOF

MINOR THERMAL BRIDGE

The relatively warm surface temperatures in Diagram **C2.1** show that there is little risk of mould growth at ceiling level. However, the thermal analysis shows that the blockwork surface temperature within the roof void falls to 6.5°C in the corner, with a risk of surface condensation.

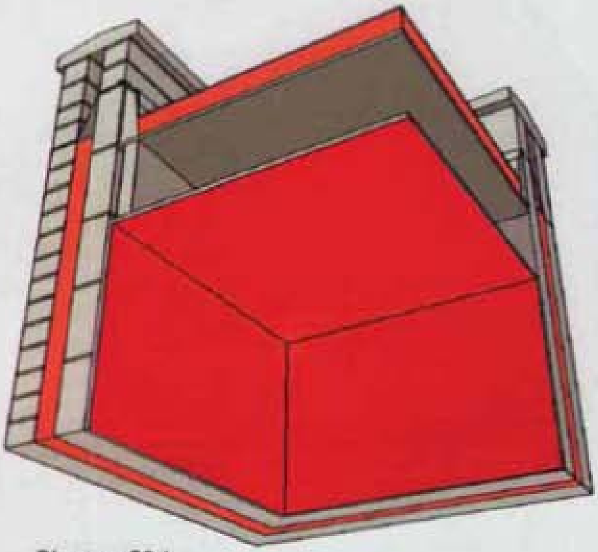


Diagram C2.1

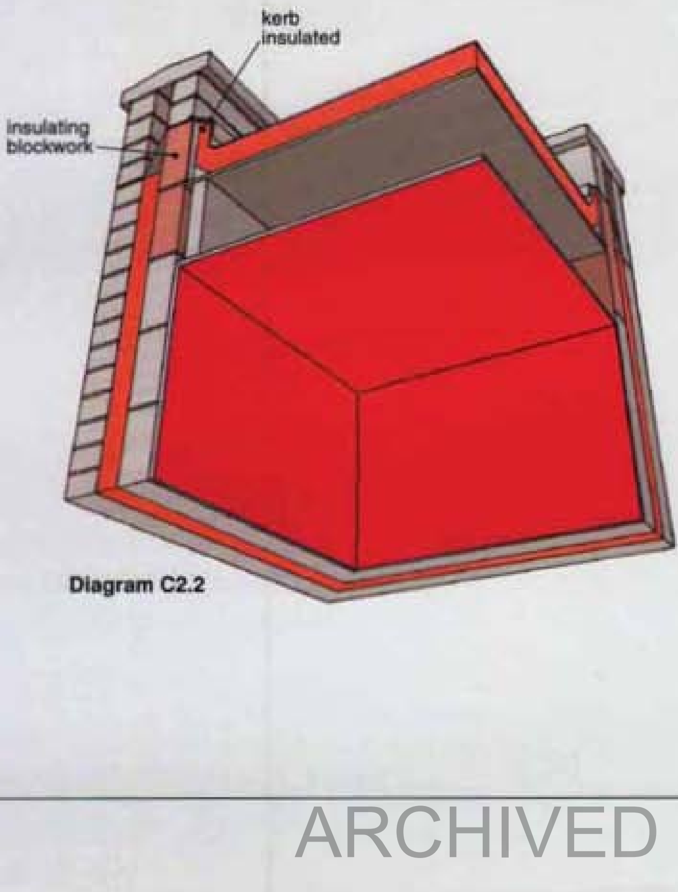


Diagram C2.2

BEST PRACTICE

Using insulating blockwork for the inner leaf makes little difference to the surface temperature at ceiling level, but raises the blockwork surface temperature by 0.5°C.

Best results are obtained by turning up the roof insulation at the perimeter upstand, as in Diagram **C2.2**. This helps to extend the length of the thermal bridge path and raises the blockwork surface temperature to 8.0°C. In addition, a vapour control layer should be incorporated on the warm side of the insulation.

D CAVITY INSULATED WALL – TIMBER FLAT ROOF

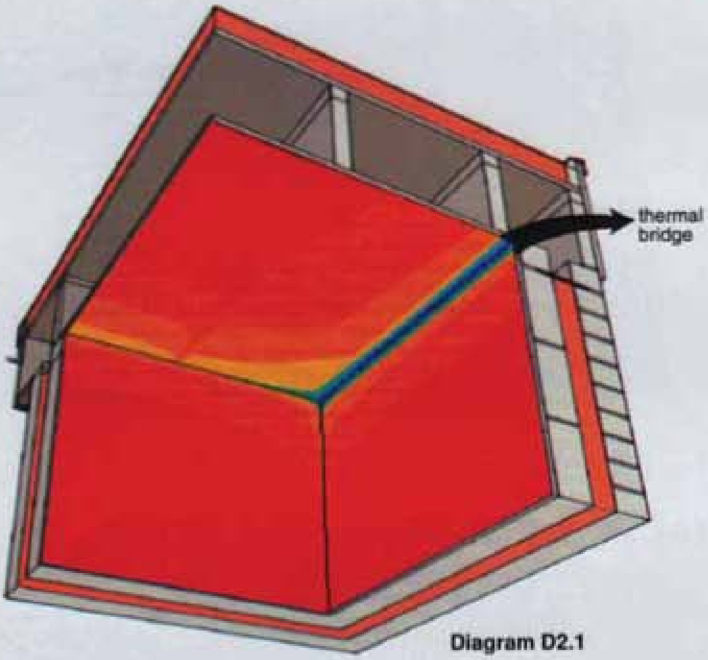


Diagram D2.1

MAJOR RISK OF MOULD

The need for continuity between cavity and roof insulation is shown clearly in Diagram **D2.1**, where the thermal bridge creates a high risk of mould growth at the verge.

BEST PRACTICE

Adding insulation in the roof void, as shown in Diagram **D2.2**, increases surface temperatures dramatically.

The continuity between the roof and wall insulation at the eaves **(A)** produces warmer surface temperatures than at the verge **(B)** where there is a break in the insulation. Extending the insulation at the verge to provide continuity over the wall plate would raise surface temperatures to the same level as those achieved at the eaves.

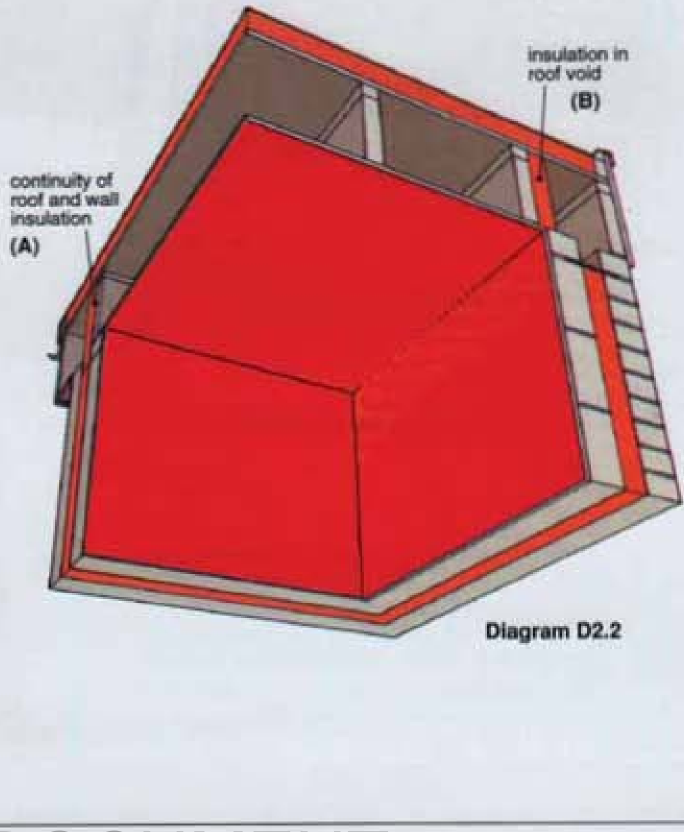


Diagram D2.2

E INTERNALLY INSULATED PARAPET WALL – CONCRETE FLAT ROOF

SLIGHT RISK OF MOULD

With no ceiling insulation a thermal bridge is unavoidable with this parapet detail. Diagram **E2.1** shows there is a slight risk of mould growth in the corner. There is also a risk of interstitial condensation on the surface of the concrete slab in the ceiling void. Further analysis incorporating ceiling insulation was not undertaken.

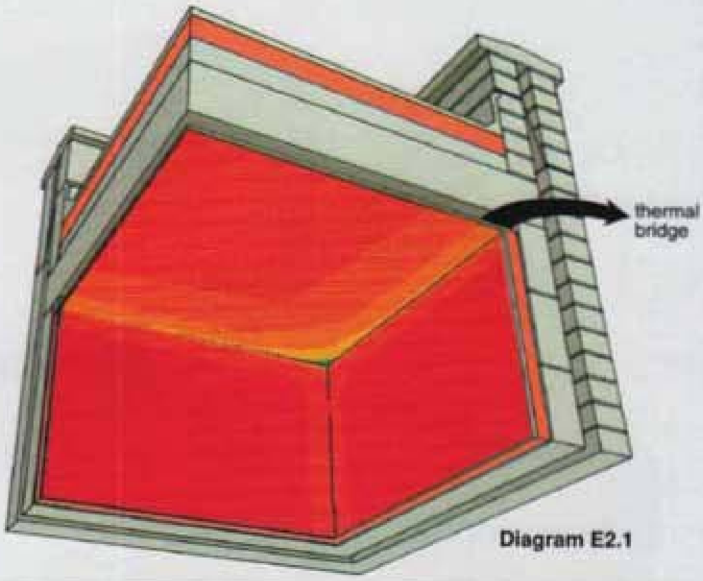


Diagram E2.1

F INTERNALLY INSULATED WALL – CONCRETE FLAT ROOF

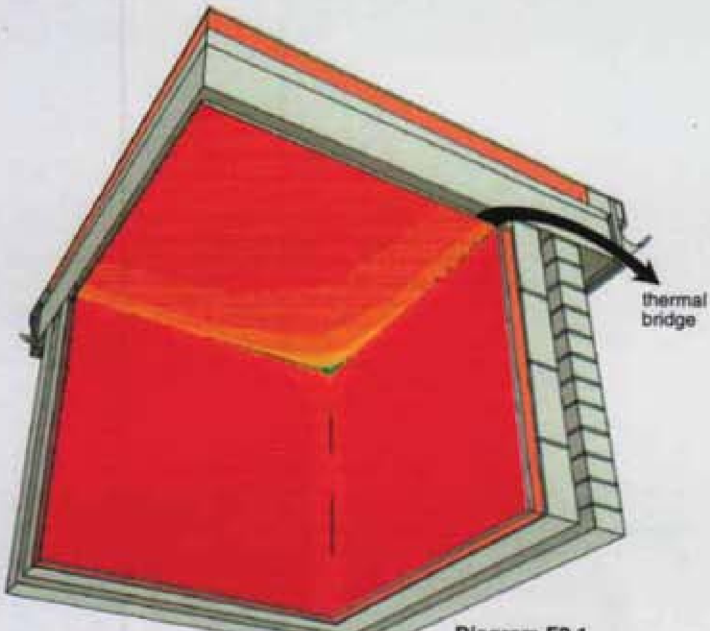


Diagram F2.1

SLIGHT RISK OF MOULD

As detailed in Diagram **F2.1**, the concrete roof slab creates a classic thermal bridge, with a slight risk of mould growth in the corner.

MINOR THERMAL BRIDGE

Covering the exposed edges of the concrete roof slab with insulation, as in Diagram **F2.2**, raises surface temperatures significantly. However, the thermal analysis shows that the surface temperature of the concrete slab behind the plasterboard ceiling falls as low as 6.5°C in the corner. It is therefore recommended that the plasterboard ceiling incorporates a vapour control layer to minimise the risk of condensation on the underside of the concrete slab.

Diagram F2.2

G INTERNALLY INSULATED PARAPET WALL – TIMBER FLAT ROOF

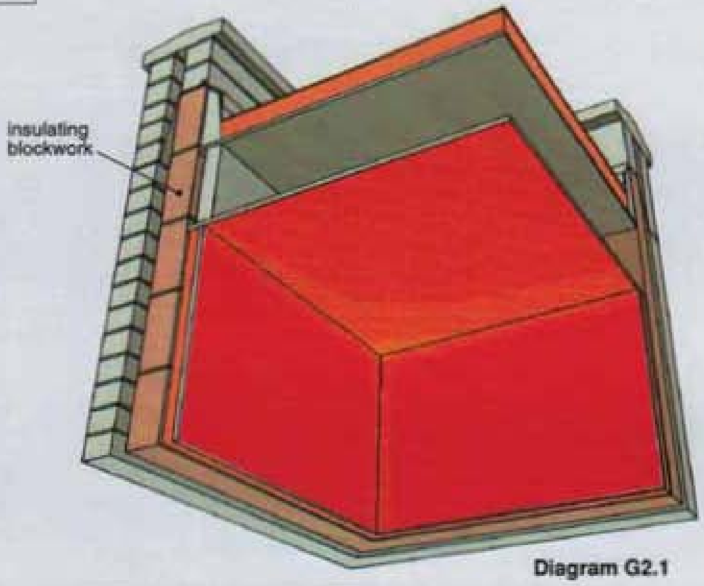


Diagram G2.1

MINOR THERMAL BRIDGE

In Diagram **G2.1**, the room surface temperatures are high enough for there to be little risk of mould growth. The use of insulating blockwork for the inner leaf helps to avoid a serious thermal bridge between the wall and roof insulation. However, it is recommended that a vapour control layer is incorporated on the warm side of the insulation to minimise the risk of condensation on the surface of the inner leaf within the roof space.

H INTERNALLY INSULATED WALL – TIMBER FLAT ROOF

SLIGHT RISK OF MOULD

The lack of continuity between the roof and wall insulation, as shown in Diagram **H2.1**, results in a mould growth risk at the ceiling/wall junction.

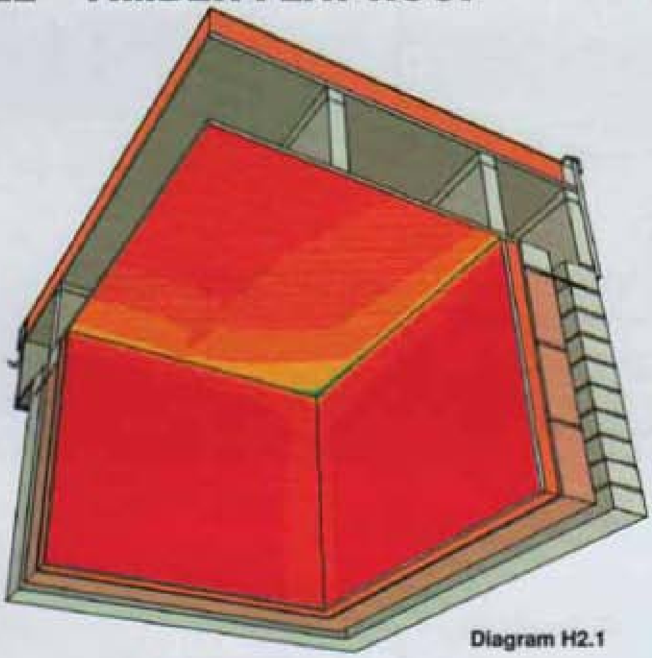


Diagram H2.1

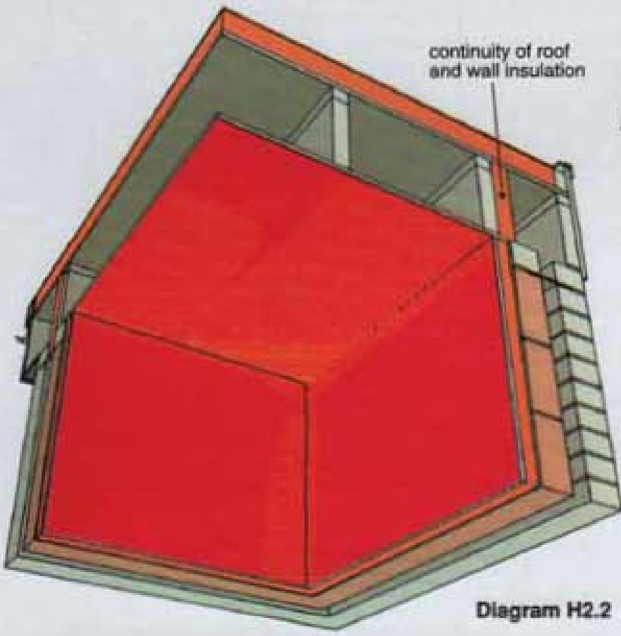


Diagram H2.2

BEST PRACTICE

Linking the roof and wall insulation, as shown in Diagram **H2.2**, gives almost total continuity of insulation and avoids a thermal bridge.

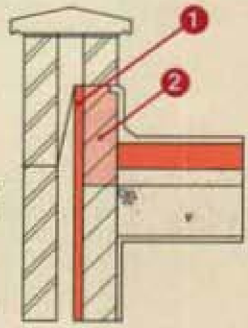
SUMMARY OF RECOMMENDATIONS

Wall insulation	Concrete roof	Timber roof

Cavity insulated wall

Concrete roof

A Parapet detail

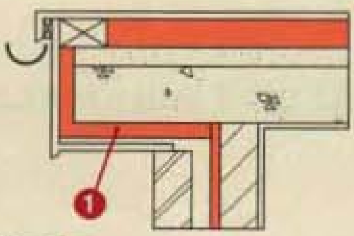


Best Practice

1 Take the cavity insulation up to at least the level of the roof insulation, AND

2 Use insulating blockwork in the thermal bridge path.

B Eaves detail

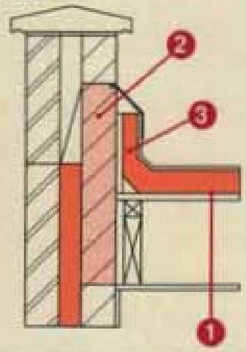


Best Practice

1 Provide a continuous link between the roof and wall insulation.

Timber roof

C Parapet detail



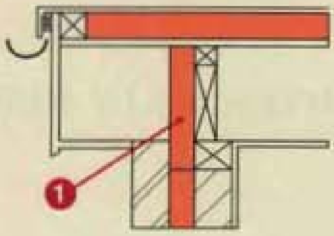
Best Practice

1 Incorporate a vapour control layer on the warm side of the insulation

2 Use insulating blockwork for the inner leaf, AND

3 Turn the roof insulation up the kerb.

D Eaves detail



Best Practice

1 Add insulation within the roof void.

Internally insulated wall

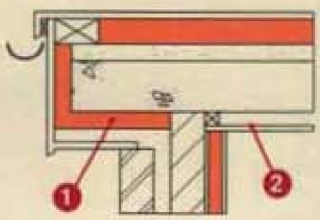
Note: Internal insulation should include a vapour check on the warm side of the insulation

Concrete roof

E Parapet detail

Diagram E2.1 on page 14 is not recommended. Consider an alternative solution.

F Eaves detail



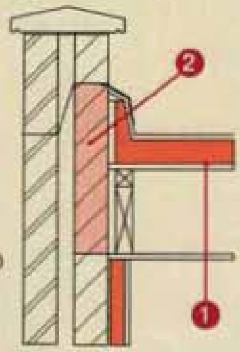
Minimum recommendations

1 Continue the roof insulation along the soffit of the concrete roof, AND

2 Incorporate a vapour control layer at ceiling level.

Timber roof

G Parapet detail

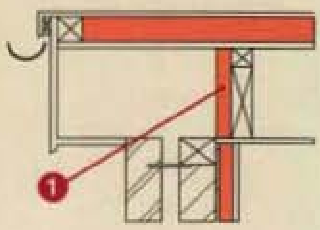


Minimum recommendations

1 Incorporate a vapour control layer on the warm side of the insulation, AND

2 Use insulating blockwork for the inner leaf.

H Eaves detail



Best Practice

1 Add insulation within the roof void to link the wall and roof insulation.

Note: 'Minimum recommendations' provide advice on reducing the risk of mould growth occuring.

Cavity insulated walls and window details

Introduction

Cavity insulated walls are an economic way of achieving a U-value of 0.45 W/m²K or better. This chapter looks at the potential thermal bridges that occur in commonly used details at window openings and at the junction with a pitched roof.

Two forms of cavity insulation have been used in the illustrations:

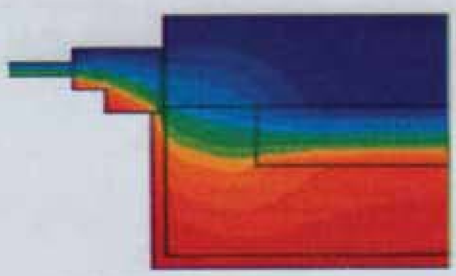
- a 65 mm wide cavity fully filled with mineral wool batts
- a partially filled cavity with a 25 mm thick foil-faced, phenolic foam board.

Both constructions achieve a U-value of 0.45 W/m²K when used with a medium density block for the inner leaf.

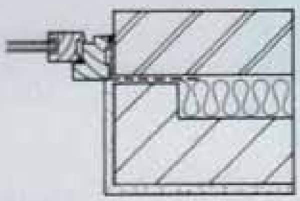
Many commonly used details have thermal bridges, especially at window openings. The cross-sections below contrast two jamb details. In the upper illustration, with the window forward and an uninsulated jamb return, there is a clear thermal bridge. In the lower illustration, the use of an insulated cavity closer and positioning the window in the same plane as the cavity insulation avoids a weakness in the insulating layer.

The results on the following pages illustrate the advantages of:

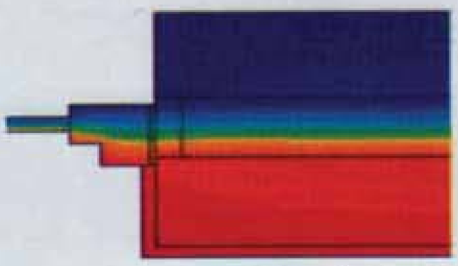
- using details at window openings that allow continuity of the insulation up to the back of the window frame
- setting the window frame well back from the outer leaf to lap insulation at the lintel and jamb positions
- using blocks with a low conductivity where the blockwork forms a break in the insulation, such as at gable walls.



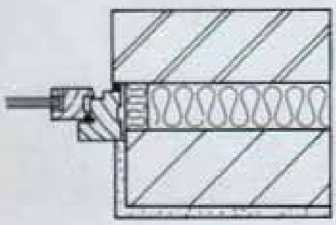
Section through uninsulated jamb (window forward)



Construction detail



Section through jamb with insulated cavity closer (window in rebated position)



Construction detail

A STEEL BOX LINTEL

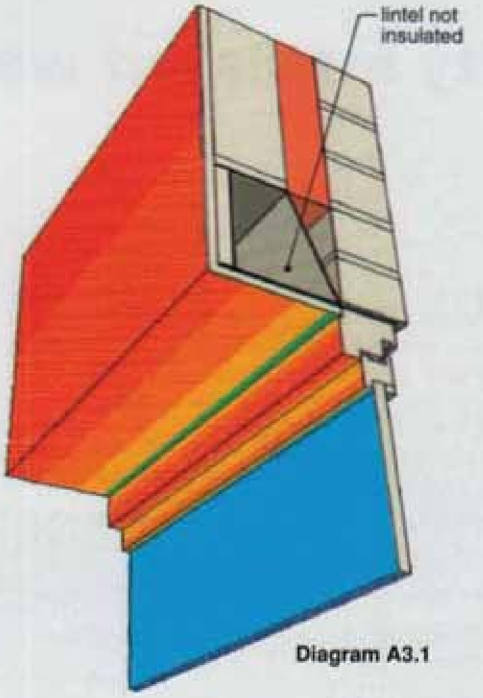


Diagram A3.1

SLIGHT RISK OF MOULD

With no insulation around the box lintel as in Diagram **A3.1**, a thermal bridge exists and there is a slight risk of mould forming at the junction of the soffit and window frame, but all wall surfaces are warmer than the double glazing.

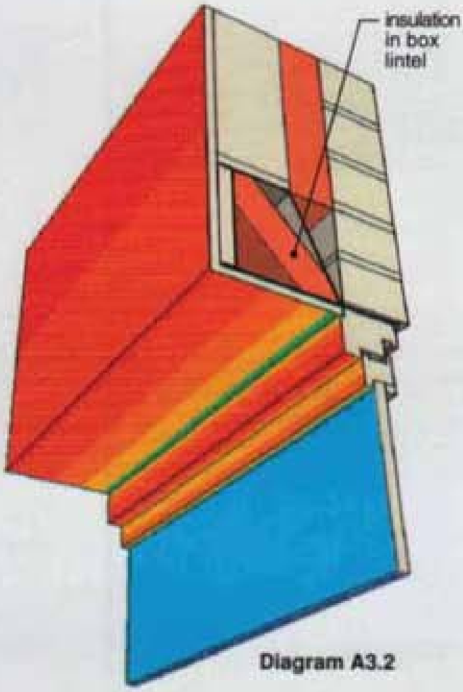


Diagram A3.2

SLIGHT RISK OF MOULD

In Diagram **A3.2**, insulation placed in the box lintel has little effect on the risk of mould. At first this seems a surprising result. On further analysis, it appears that the insulation has the effect of insulating the outer steel members from the room heat. Conduction from the cold outer steel members has the effect of cancelling out the benefit of the lintel insulation at the critical window/soffit junction.

BEST PRACTICE

The best results are achieved by combining soffit insulation with cavity insulation, as shown in Diagram **A3.3**. Filling the cavity in front of the lintel can be achieved by blowing beads, foam or fibres into the cavity. Shaping insulation batts to fit the triangular shape needs care but can be achieved by progressively cutting and delaminating the fibres of the cavity insulation batts.

Placing insulation at the soffit level raises the soffit temperature dramatically. With drylining, using an insulation-backed plasterboard is straightforward – a board with 13 mm of expanded polystyrene would be sufficient. With a wet plaster finish, it is necessary to cover the insulation with expanded metal to provide a key for the plaster.

It must be ensured that the joint between the plaster or plasterboard lining and the window frame is sealed to minimise the risk of condensation on the cold steel.

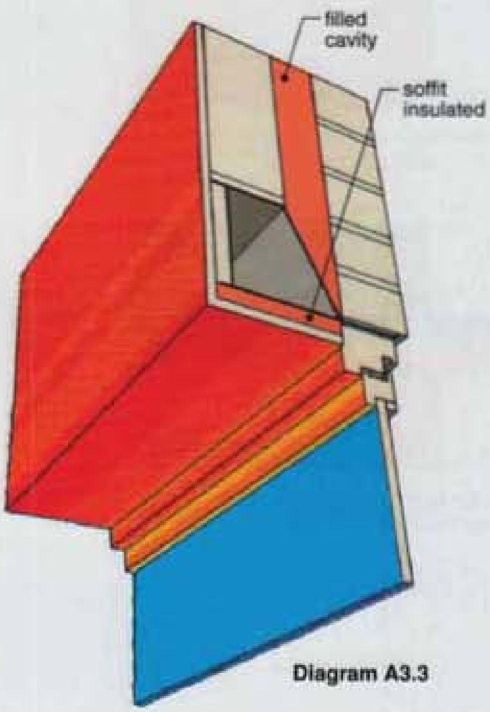


Diagram A3.3

B FOLDED STEEL LINTEL

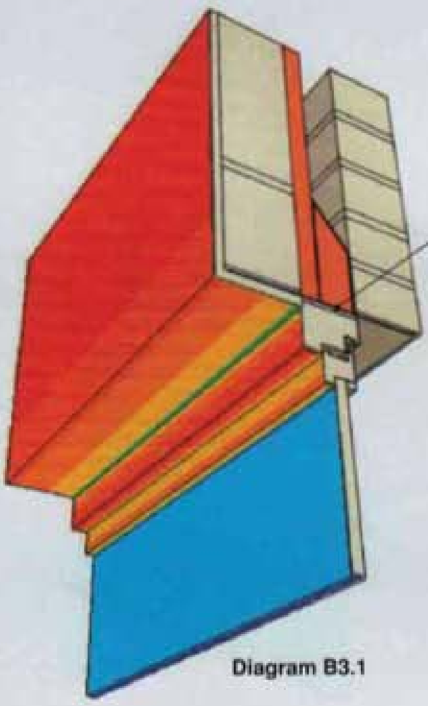


Diagram B3.1

RISK OF MOULD

Diagram **B3.1** shows the adverse effect of reinforcing the lower steel members with a continuous steel plate. Most ranges of folded steel lintels have a reinforcing plate in this position for larger spans or heavily loaded lintels.

SLIGHT RISK OF MOULD

This type of lintel is becoming an increasingly popular way of providing insulation at the window head. However, with the window placed forward, as in Diagram **B3.2**, the temperatures at the crucial window/soffit junction are low enough for there to be a slight risk of mould growth, even though the majority of the wall and soffit surfaces are warmer than with the open box lintel shown in Diagram **A3.1**.

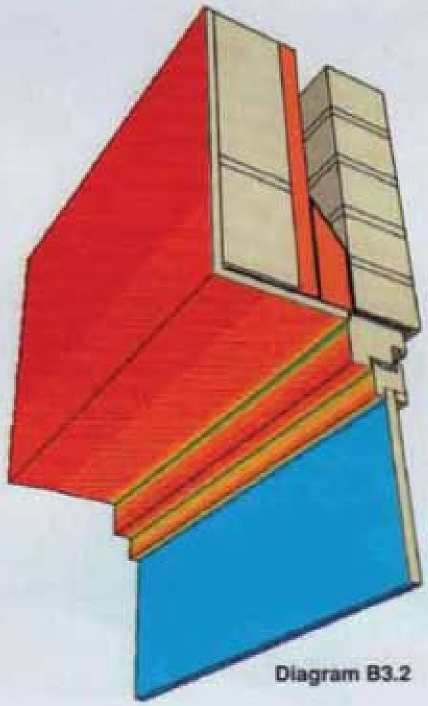


Diagram B3.2

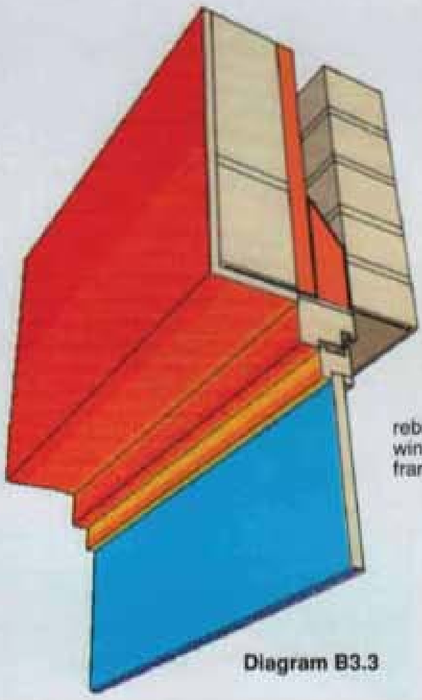


Diagram B3.3

BEST PRACTICE

The lowest risk of mould occurs with the window frame in the rebated position, as in Diagram **B3.3**.

C AIRCRETE LINTEL

SLIGHT RISK OF MOULD

The lintel used in this example has a density of 480 kg/m^3, ie lightweight aircrete.

The aircrete lintel is equally as sensitive to the position of the window frame as the insulated folded steel lintel in construction B.

With the window forward, as in Diagram **C3.1**, there is a slight risk of mould growth.

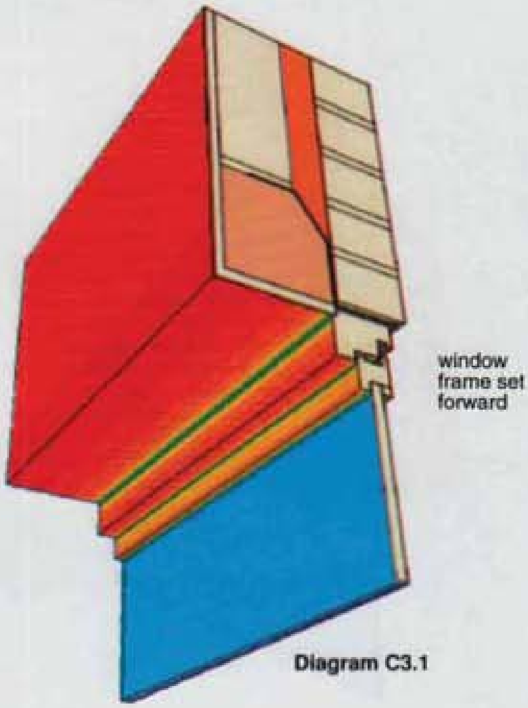


Diagram C3.1

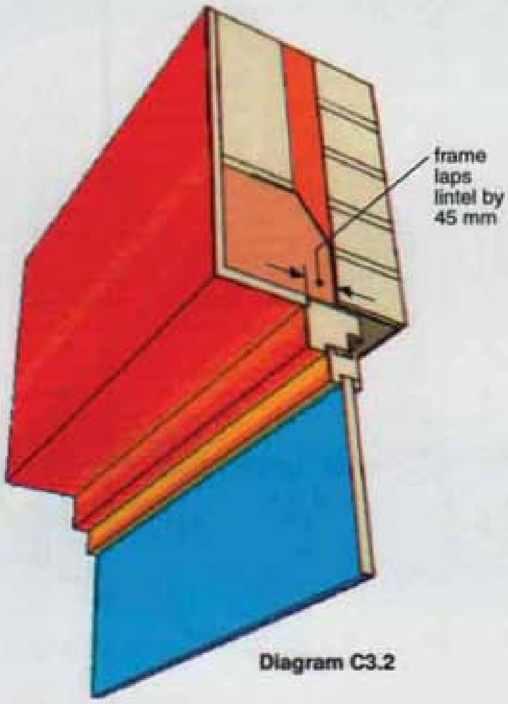


Diagram C3.2

MINOR THERMAL BRIDGE

Setting the window back to give a 45 mm overlap, as in Diagram **C3.2**, raises the minimum temperature at the window/soffit junction by over 2°C.

BEST PRACTICE

The warmest room surfaces are obtained with the window in the rebated position, as in Diagram **C3.3**. However, as the window is moved back, more of the steel lintel is exposed to the outside air. The lower surface temperatures at the lintel/blockwork junction are a direct consequence of the increased proportion of highly conductive steel being cold. The thermal analysis shows that the temperature of the innermost edge of the steel is 6.9°C in Diagram **C3.3** compared with 9.1°C in Diagram **C3.1**.

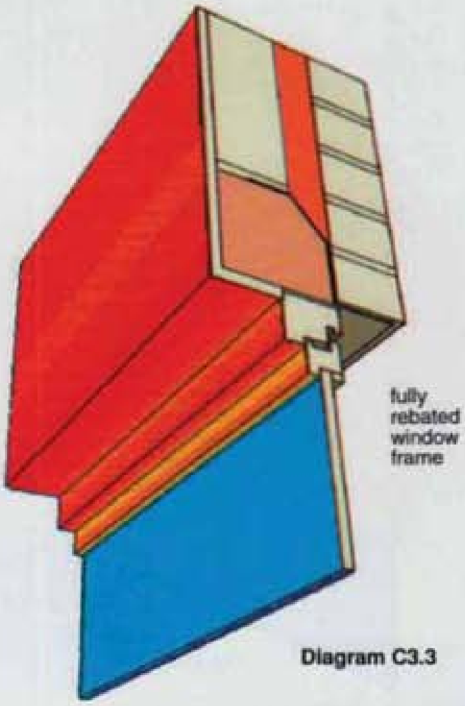


Diagram C3.3

D JAMB AND SILL – BLOCKWORK RETURNED

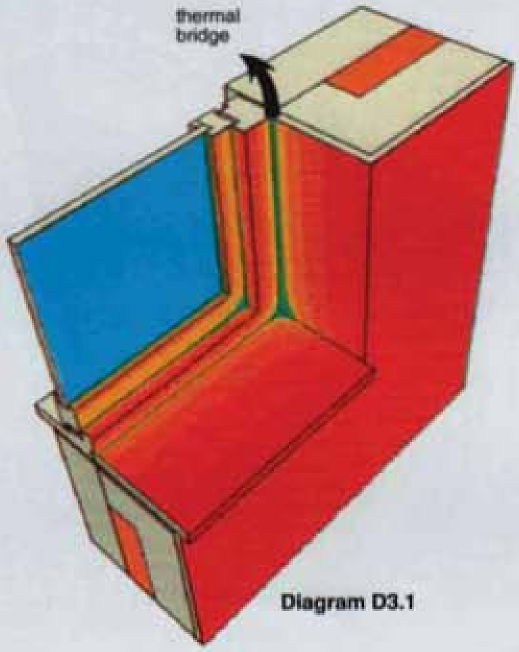


Diagram D3.1

RISK OF MOULD

It is very common in the more sheltered parts of the country for the window frame to be placed forward, within the thickness of the outer leaf, as in Diagram **D3.1**. With the window in this position it is very difficult to eliminate thermal bridging.

Diagram **D3.1** shows a classic thermal bridge at the jamb due to the masonry inner leaf bridging the cavity. The inner leaf in this example is a medium density block. However, even using lightweight aircrete does not prevent a thermal bridge with this detail.

SLIGHT RISK OF MOULD

Insulating the reveal, as in Diagram **D3.2** is the most successful way of raising surface temperatures where the window frame is within the thickness of the outer leaf, but even here the thermal analysis shows that temperatures drop to below 12°C at the junction of the jamb and window sill.

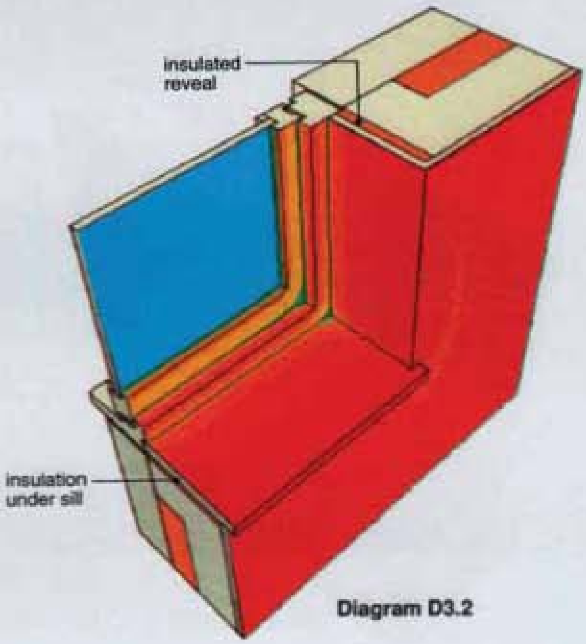


Diagram D3.2

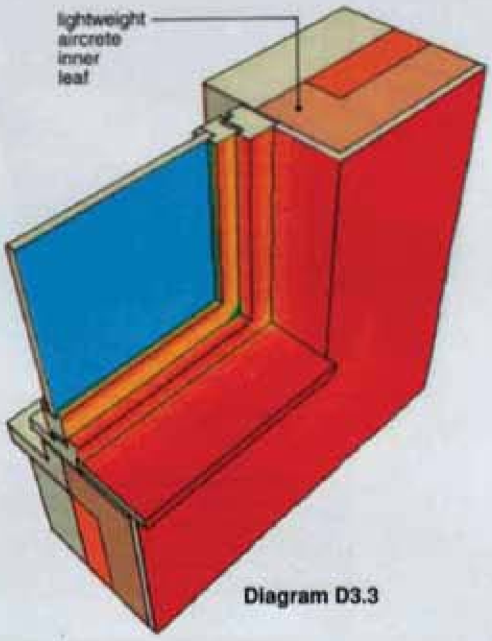


Diagram D3.3

MINOR THERMAL BRIDGE

An alternative solution is to set the window frame back from the outer leaf so that the cavity insulation and glazing are virtually in the same plane. In Diagram **D3.3** the window frame 'overlaps' the inner leaf by 45 mm. Changing the block from medium density to a lightweight aircrete block raises surface temperatures substantially. The best result is achieved with the window in the rebated position.

E JAMB AND SILL – INSULATION BEHIND DAMP PROOF COURSE

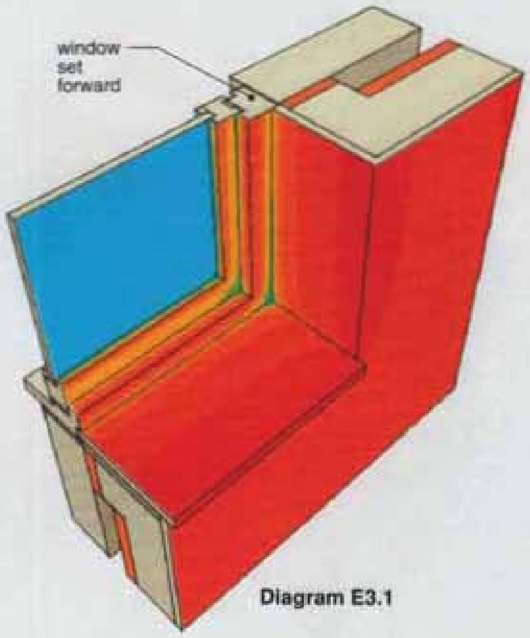


Diagram E3.1

SLIGHT RISK OF MOULD

Placing 20 mm of expanded polystyrene immediately behind the dpc makes a dramatic difference compared with the simple blockwork return shown in junction D. However, with the window in a forward position, as in Diagram **E3.1**, there is still a slight risk of mould growth.

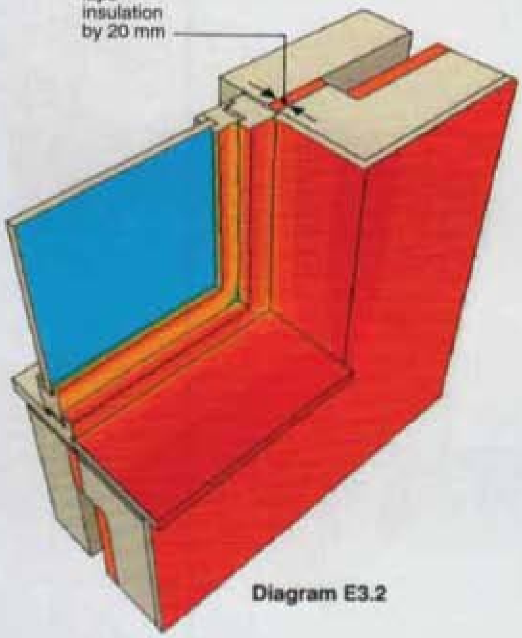


Diagram E3.2

MINOR THERMAL BRIDGE

When the window is set back 20 mm to overlap the insulation fully, as in Diagram **E3.2**, the temperature at the jamb is almost 2°C warmer.

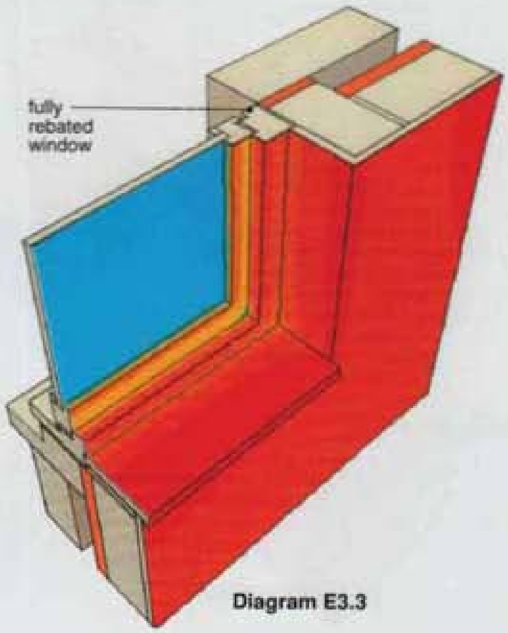


Diagram E3.3

BEST PRACTICE

With a fully rebated window, as in Diagram **E3.3**, the wall insulation and glazing are virtually in the same plane. All the wall surfaces are considerably warmer than the double glazing, and there is very little risk of mould growth.

F JAMB AND SILL – INSULATING CLOSER

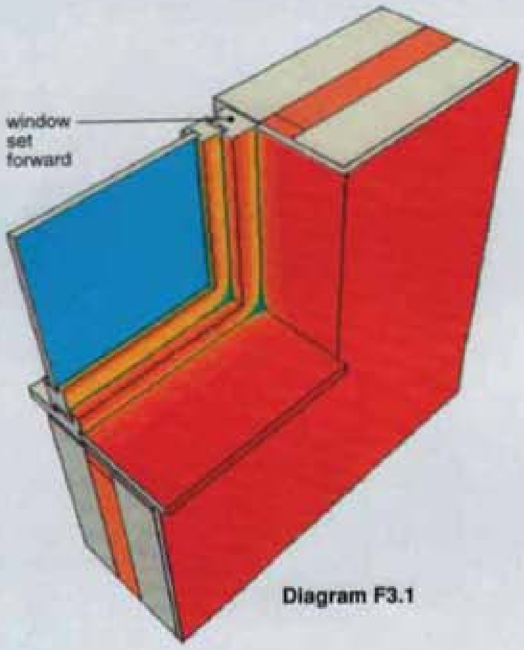


Diagram F3.1

SLIGHT RISK OF MOULD

Not surprisingly, the best results among the jamb details were achieved using an insulating closer in combination with cavity insulation, to ensure an unbroken layer of insulation right up to the back of the window frame. In contrast to details for junctions D and E, the thermal analysis shows that the surface temperature of the walls remained above 17.5°C deep into the reveals.

Even with an insulating cavity closer, however, there was a slight risk of mould growth if the window frame was forward as in Diagram **F3.1**.

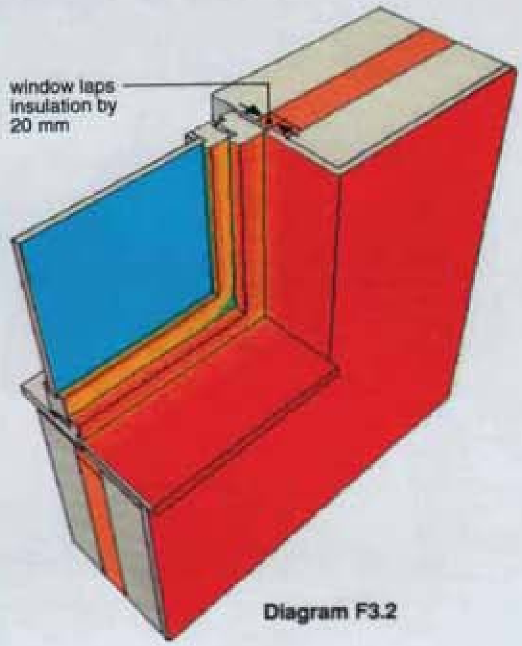


Diagram F3.2

MINOR THERMAL BRIDGE

Setting the window back to provide 20 mm overlap between window frame and insulation, as in Diagram **F3.2**, gives noticeably warmer surfaces at the critical frame/jamb junction.

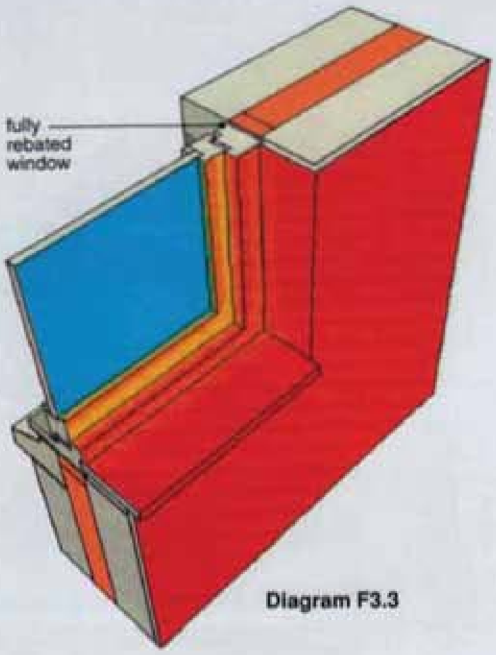


Diagram F3.3

BEST PRACTICE

With the window in the rebated position, as in Diagram **F3.3**, thermal bridging is minimised.

G GABLE WALL – JUNCTION WITH CEILING

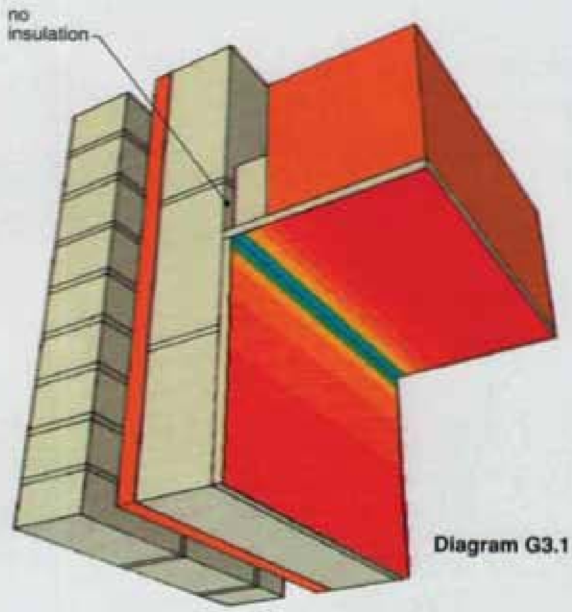


Diagram G3.1

RISK OF MOULD

The most likely position for a thermal bridge is shown in Diagram **G3.1**. Even though the roof and wall are well insulated, the failure to take the loft insulation over the ceiling joist and butt it against the gable wall results in a significant thermal bridge. At its coldest point, the ceiling in Diagram **G3.1** would be as cold as the inner surface of double glazing!

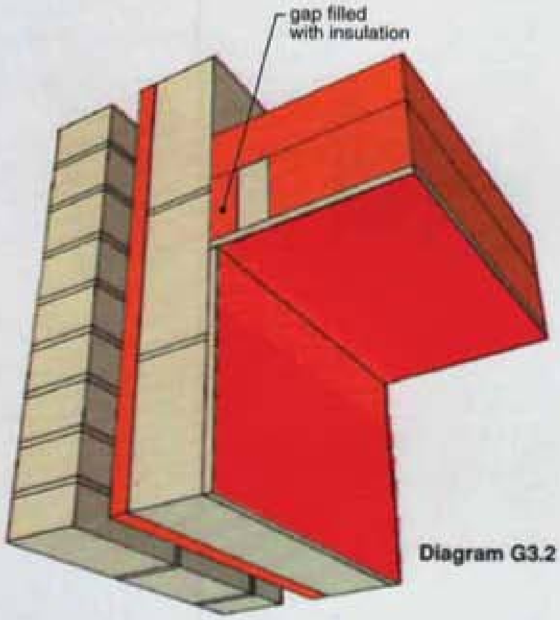


Diagram G3.2

NO THERMAL BRIDGE

A thermal bridge at the gable wall/ceiling junction is easy for the designer to overcome by placing insulation between the ceiling joist and the wall, as shown in Diagram **G3.2**.

However, pushing insulation down between the joist and the wall can be difficult to carry out satisfactorily if the gap is small. Spacing the last ceiling joist 40 to 50 mm away from the gable wall makes it easier to install the insulation.

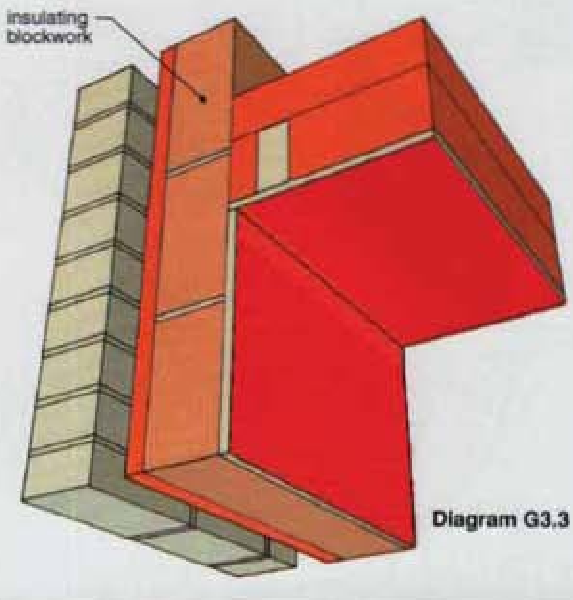


Diagram G3.3

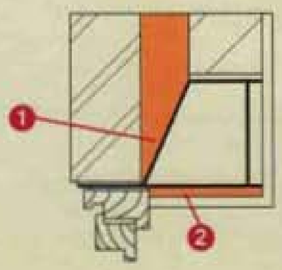
BEST PRACTICE

Using an insulating block, as shown in Diagram **G3.3**, results in a modest improvement compared with Diagram **G3.2**, but is much less important than filling the gap between the joist and the wall.

SUMMARY OF RECOMMENDATIONS AT WINDOW OPENINGS

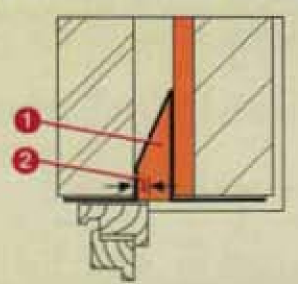
Lintel details

A Steel box lintel



Best Practice
1 Insulate cavity in front of the box lintel, AND
2 Insulate the soffit of the lintel.

B Folded steel lintel

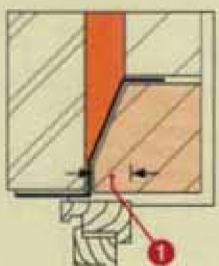


Minimum recommendations
1 Insulate lintel, AND
2 Set the window back to lap lintel insulation by at least 20 mm.

Best Practice
Insulate the lintel, AND

Place the window in the rebated position.

C Aircrete lintel

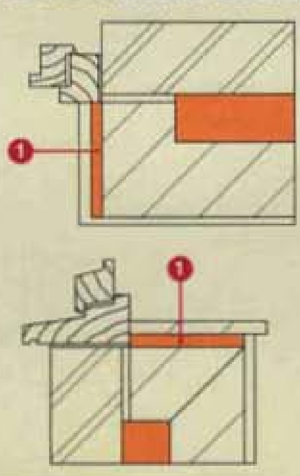


Minimum recommendations
1 Set the window back to lap the lintel by at least 45 mm.

Best Practice
Place the window in the rebated position.

Jamb and sill details

D Blockwork returned



Minimum recommendations

Window forward (as shown)

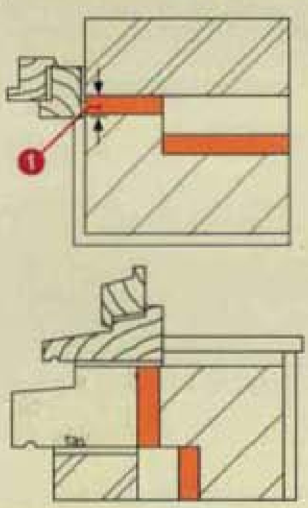
1 Insulate the window reveal and under the window board.

There is still a slight risk of mould growth when the window is forward. Setting the window back at least 45 mm, or using details E and F shown below, is recommended.

Window set back
Set the window back to:

- lap the inner leaf at least 45 mm, if lightweight aircrete is used for inner leaf, or
- the rebate position, if medium density blockwork is used for the inner leaf.

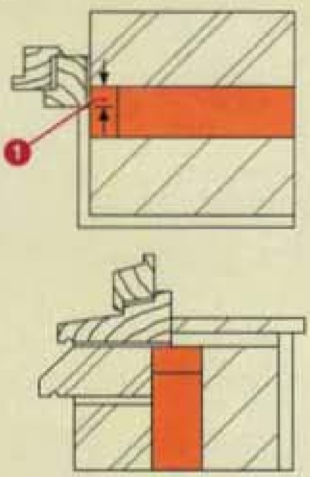
E Insulation behind dpc



Minimum recommendations
1 Set the window back to lap the insulation by at least 20 mm (as shown).

Best Practice
Place the window in the rebated position.

F Insulating closer



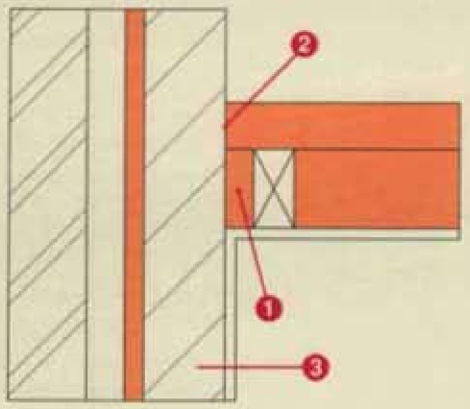
Minimum recommendations
1 Set the window back to lap the insulation by at least 20 mm (as shown).

Best Practice
Place the window in the rebated position.

Note: 'Minimum recommendations' provide advice on reducing the risk of mould growth occuring. Best Practice is the preferred option.

SUMMARY OF RECOMMENDATIONS AT GABLE WALLS

G Junction with ceiling



Minimum recommendations

1 Insulate the gap between the last ceiling joist and the wall, AND

2 Butt the top layer of loft insulation against the gable wall.

Best Practice

In addition to **1** and **2** above,

3 Use insulating blockwork for the inner leaf.

Note: 'Minimum recommendations' provide advice on reducing the risk of mould growth occuring. Best Practice is the preferred option.

Timber framed walls and window details

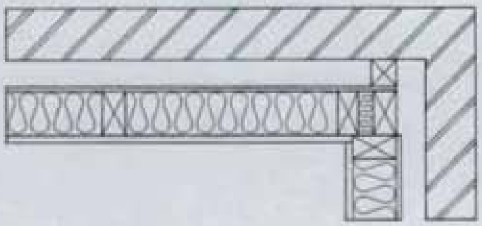
Introduction

The timber framed wall construction used in this chapter uses 90 x 45 mm timber studs with 90 mm thick mineral wool insulation between the studs. This achieves a U-value of just under 0.4 W/m^2K, after taking into account the bridging by the timber members.

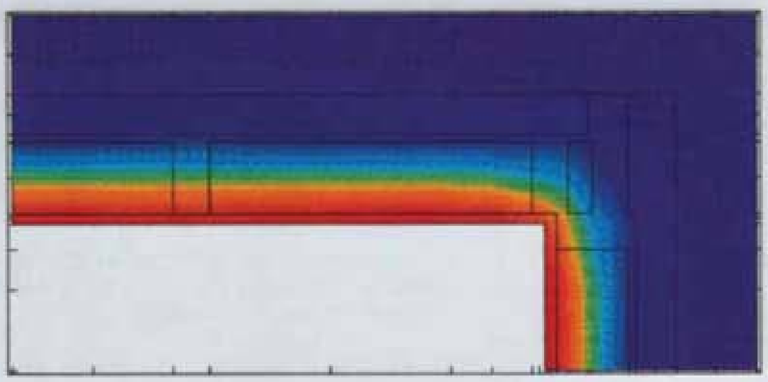
The interruption of the insulation layer by the timber members does result in a modest thermal bridge, which is barely evident in the section shown below.

The concentration of timber studs at the external corner lowers the surface temperature in the corner by about 3.5°C. Even here, however, temperatures were shown by the thermal analysis to be high enough to avoid the risk of mould growth.

The lowest surface temperatures were recorded at window openings, where the window frame was set forward to mask the 50 mm cavity between the brickwork and the timber framed wall panels.



Construction detail



Horizontal section through corner of timber framed wall

A LINTEL DETAIL

SLIGHT RISK OF MOULD

Current practice among many timber frame manufacturers is for windows and doors to project forward of the timber frame wall panel, as shown in Diagram **A4.1**. In this position, the window extends across the cavity between the timber frame and the brick cladding. Even with a timber firestop in the thermal bridge path, the surface temperature close to the window was shown by the thermal analysis to be only just above 13.5°C.

As in Diagram **B4.1** opposite there is a slight risk of mould growth in the corner of the reveal.

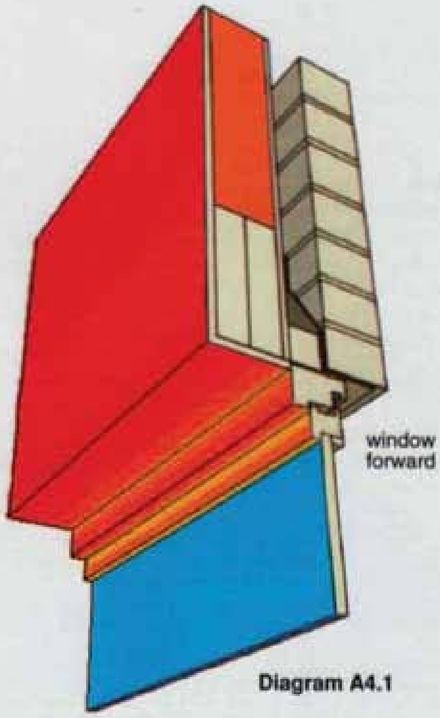


Diagram A4.1

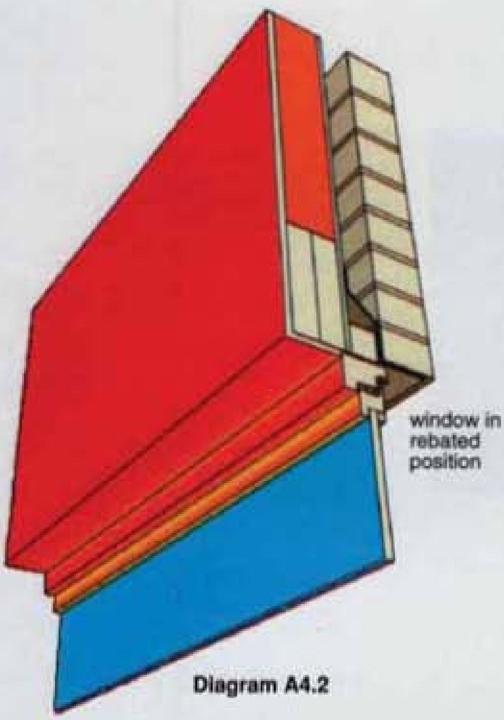


Diagram A4.2

BEST PRACTICE

Setting the window back into the rebated position, as shown in Diagram **A4.2**, reduces the thermal bridge and raises the minimum surface temperature noticeably.

B JAMB AND SILL DETAILS

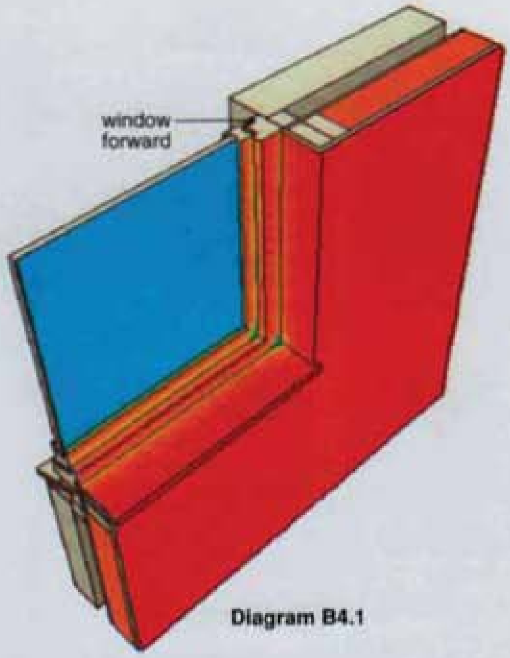


Diagram B4.1

SLIGHT RISK OF MOULD

Diagram **B4.1** shows that with the window placed well forward there is a minor thermal bridge and a small area at risk of mould growth in the corner. The thermal bridging effect of the doubled studs at the window jamb can be clearly seen.

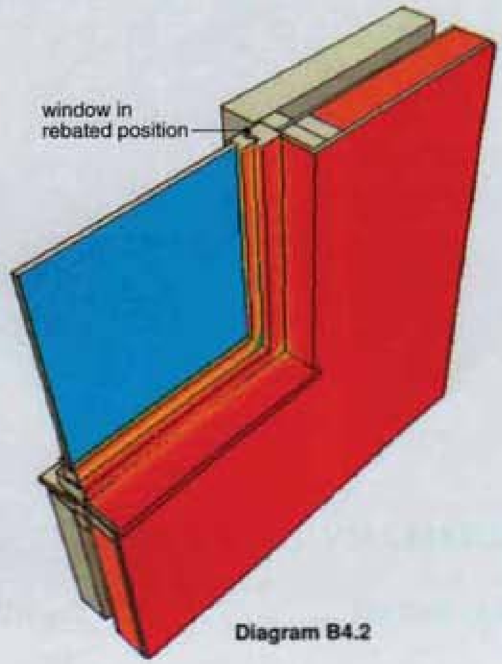


Diagram B4.2

SLIGHT RISK OF MOULD

Setting the window back into the rebated position, as in Diagram **B4.2**, increases the surface temperatures at the jamb and sill, but the risk of mould growth at the corner is still present.

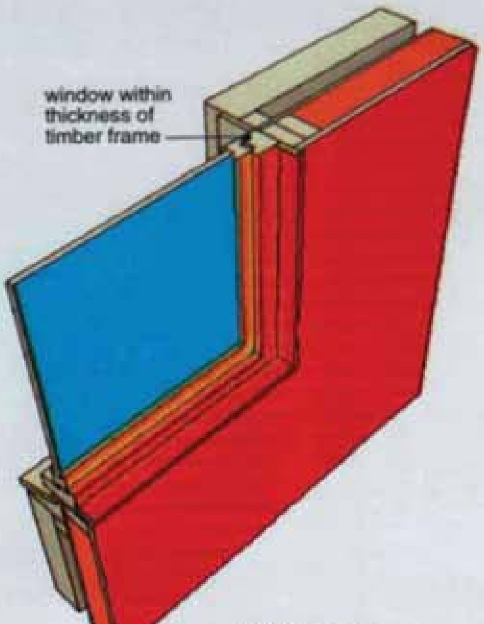


Diagram B4.3

BEST PRACTICE

Setting the window frame back so that it is within the thickness of the timber frame panel, as in Diagram **B4.3**, minimises the thermal bridge and avoids the risk of mould growth. This is achieved because the double glazing and the wall insulation are almost in the same plane. However, this detail does require an external lining to mask the wall cavity and modification to the commonly used sill details.

Its advantages are that factory fitted windows and doors in this position are less likely to be damaged in transit. Sealing the joint between the window frame and wall panel to reduce air infiltration is also easier with the window in this position.

C CORNER DETAIL

MINOR THERMAL BRIDGE

In any wall construction, the corner is always colder than adjacent wall surfaces. With timber framed construction, this weakness is compounded because the timber framing at the corner interrupts the continuity of the insulation.

Diagram **C4.1** shows the typical corner detail, with insulation omitted from the small gap between the studs. The surface temperature at the corner can be 3.5°C colder than on the adjacent main wall area.

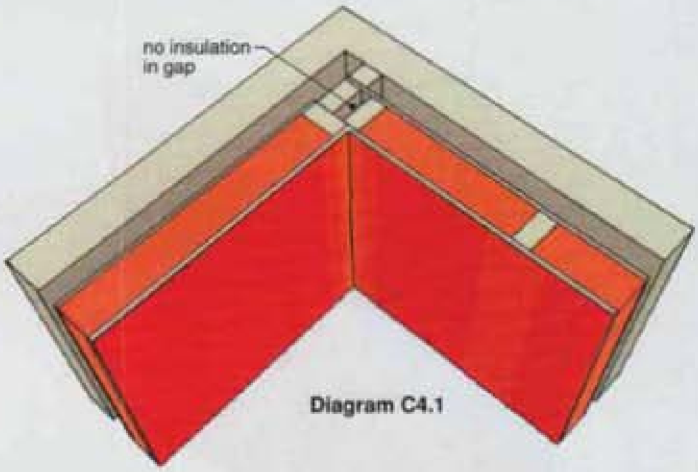


Diagram C4.1

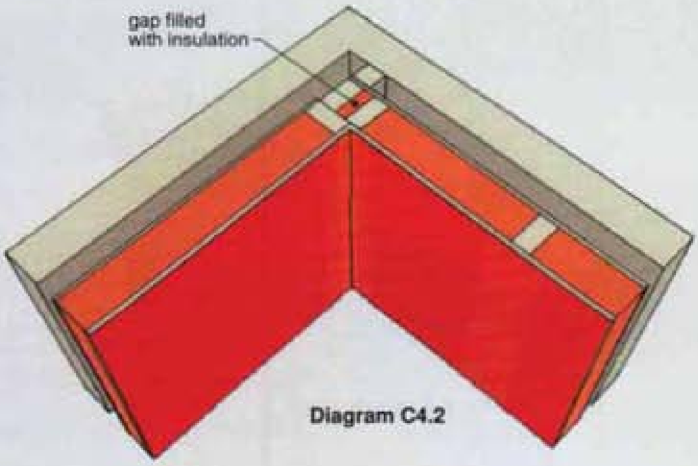


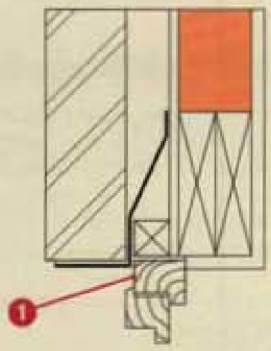
Diagram C4.2

BEST PRACTICE

Insulating the gap, as in Diagram **C4.2**, raises the surface temperature at the corner by 0.5°C.

SUMMARY OF RECOMMENDATIONS AT WINDOW OPENINGS

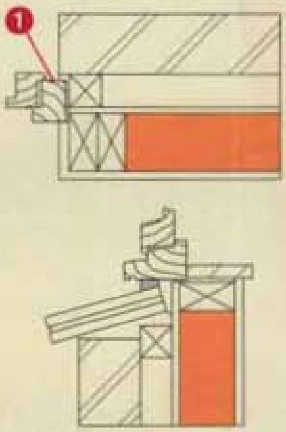
A Lintel detail



Best Practice

1 Set the window back so that it is in the rebated position.

B Jamb and sill detail



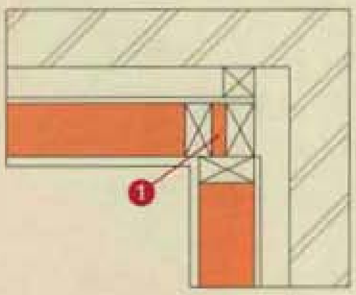
Best Practice

1 Set the window back so that it is in rebated position.

Note

The window frame can be set further back as in Diagram **B4.3**. However, this detail would require an external lining to mask the wall cavity.

C Corner detail



Best Practice

1 Fill all gaps at the corner with insulation.

Internally insulated walls and window details

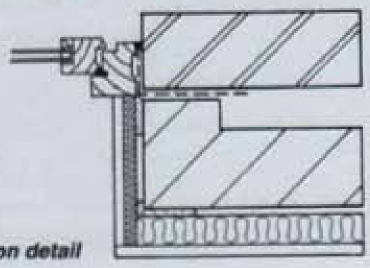
Introduction

The constructions in this chapter use a 50 mm thick laminate, consisting of 38 mm thick insulation (with a conductivity of 0.27 W/m·K) bonded to 12 mm plaster board, fixed on adhesive dabs. To achieve a U-value of 0.45 W/m^{2}K, insulating blocks are used for the inner leaf.

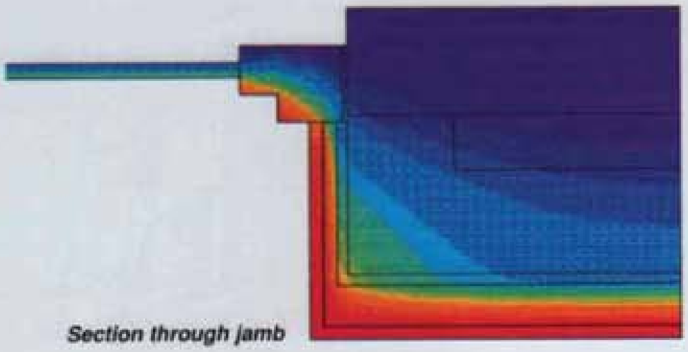
The most obvious thermal bridge with this form of construction is at the junction with a masonry partition or separating wall. Details of junctions with separating walls are shown in Chapter 12.

Although the thermal analysis showed that surface temperatures were lower where the insulating layer was interrupted at the junction of a blockwork partition with the external wall, the lowest surface temperatures were at window openings. Indeed, it was very difficult to avoid a small risk of mould growth at the junction of the reveal and the window board.

The section through a jamb detail, shown below, illustrates the problem. The thermal contours are concentrated in the insulation layer, close to the internal surface. Where the insulating layer changes direction, the contours try to take the shortest route and cut across the corner. This makes 'internal' corners particularly vulnerable. It is here that the surface temperature can be several degrees colder than the main wall area.



Construction detail



Section through jamb

A STEEL BOX LINTEL

SLIGHT RISK OF MOULD

Where the internal insulation is omitted from the soffit and the window is placed well forward, as in Diagram **A5.1**, there is a thermal bridge and a slight risk of mould growth.

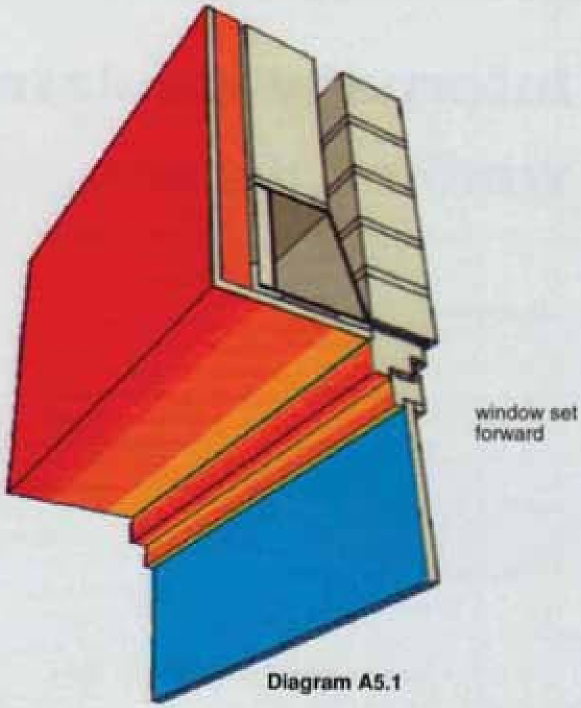


Diagram A5.1

RISK OF MOULD

Setting the window back to the rebated position, as in Diagram **A5.2**, to bring it closer to the insulated wall lining, increases the risk of mould growth. This is because, compared with Diagram **A5.1**, more of the steel lintel is exposed to the cold external air. This results in the lower steel member of the box lintel being colder and having a greater chilling effect at the critical soffit/window frame junction.

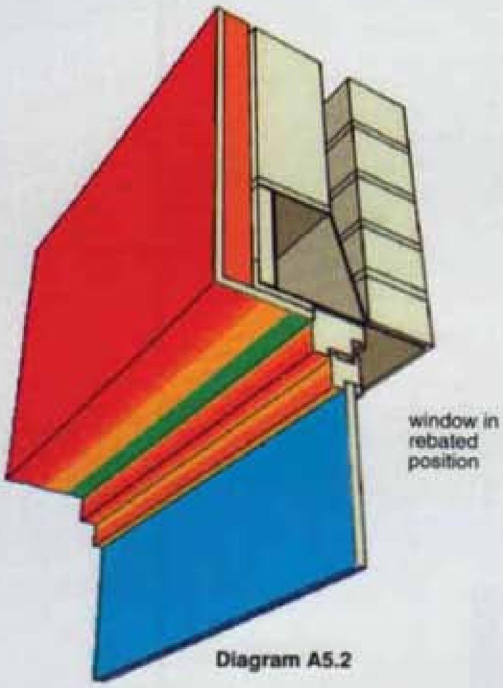


Diagram A5.2

BEST PRACTICE

Insulating the soffit, as in Diagram **A5.3**, raises the surface temperatures substantially. This example uses 13 mm of extruded polystyrene.

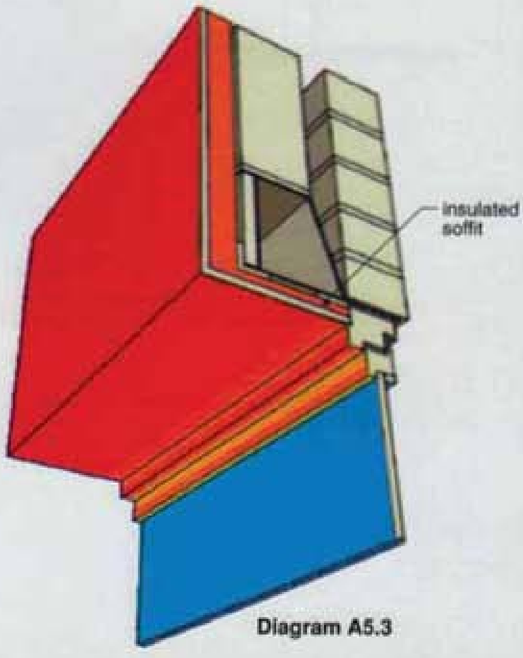


Diagram A5.3

B FOLDED STEEL LINTEL

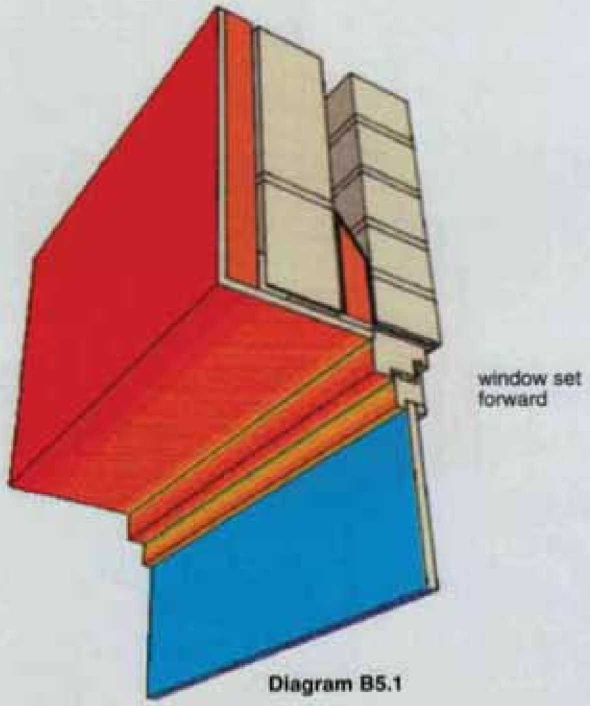


Diagram B5.1

SLIGHT RISK OF MOULD

Compared with Diagram **A5.1**, the use of an insulated folded steel lintel in Diagram **B5.1** raises the soffit temperatures substantially. However, with the window in this forward position a thermal bridge is still evident at the soffit/window frame junction. There is a slight risk of mould growth.

THERMAL BRIDGE

Setting the window back 20 mm, as in Diagram **B5.2**, reduces the thermal bridge. Setting the window frame back a greater distance would further reduce the thermal bridge.

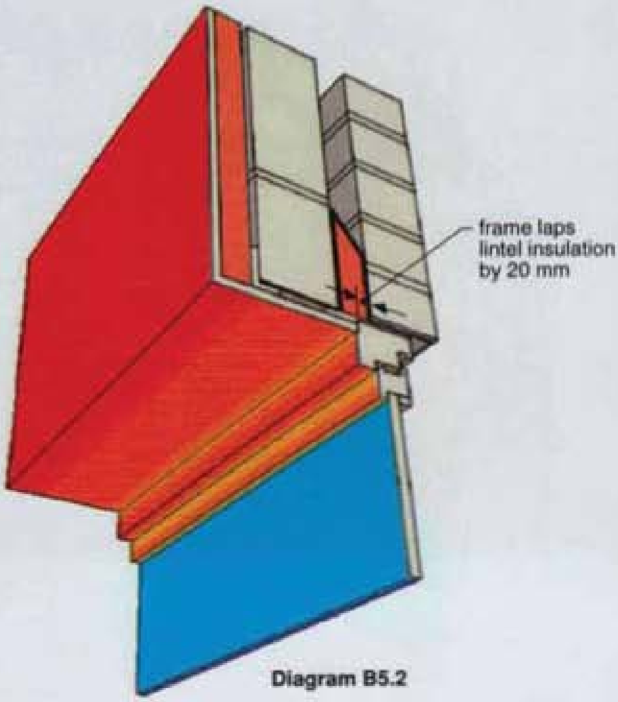


Diagram B5.2

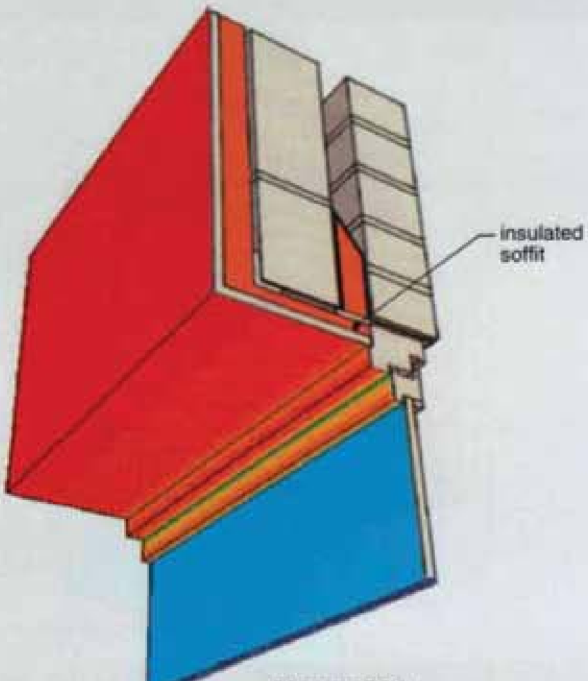


Diagram B5.3

BEST PRACTICE

Insulating the soffit, as in Diagram **B5.3**, gives the best results. This example uses 13 mm of extruded polystyrene.

C AIRCRETE LINTEL

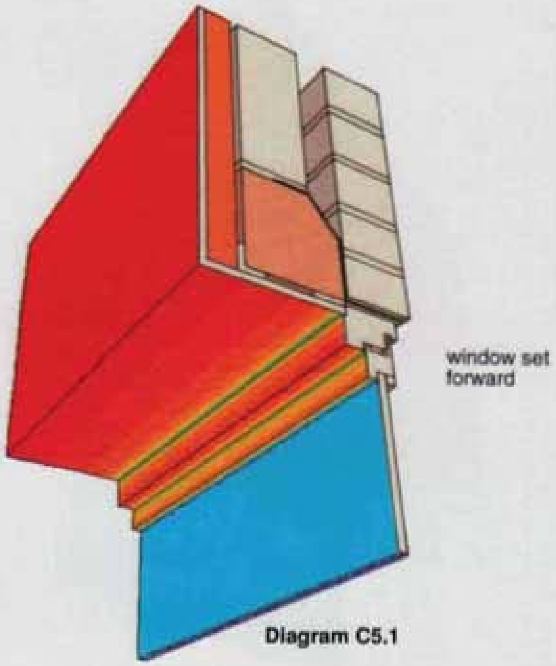


Diagram C5.1

SLIGHT RISK OF MOULD

The results for the aircrete lintel show the same pattern as for the steel lintels.

With the soffit uninsulated and the window well forward, as in Diagram **C5.1**, a thermal bridge exists at the soffit/window frame junction. There is a slight risk of mould growth.

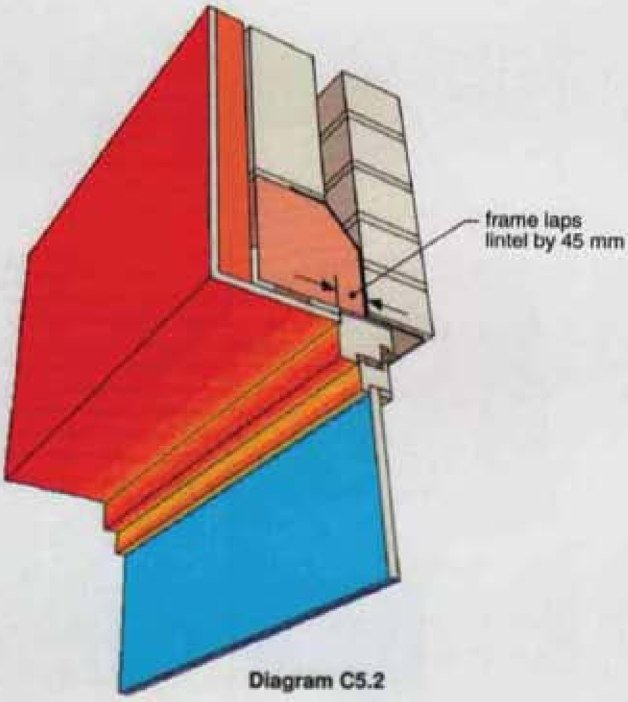


Diagram C5.2

THERMAL BRIDGE

Setting the window back 45 mm, as in Diagram **C5.2**, raises the temperature at the junction of the soffit and the window frame sufficiently to minimise the risk of mould growth.

Marginally better results can be achieved by insulating the soffit.

BEST PRACTICE

The best results are achieved by setting the window back and insulating the soffit, as in Diagram **C5.3**.

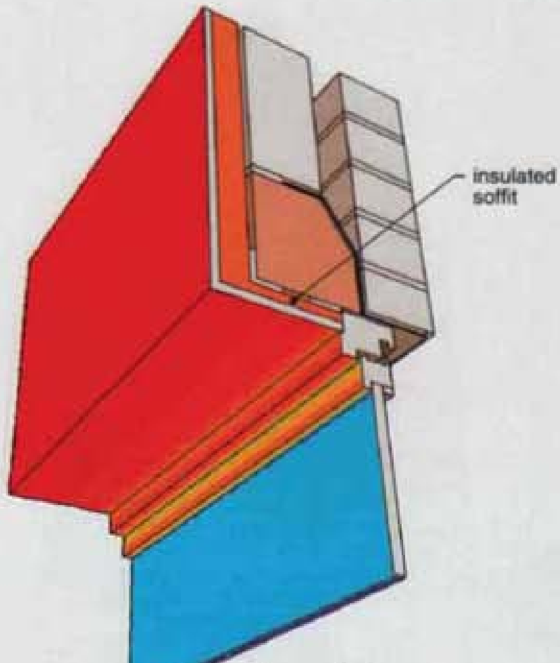


Diagram C5.3

D JAMB AND SILL – BLOCKWORK RETURNED

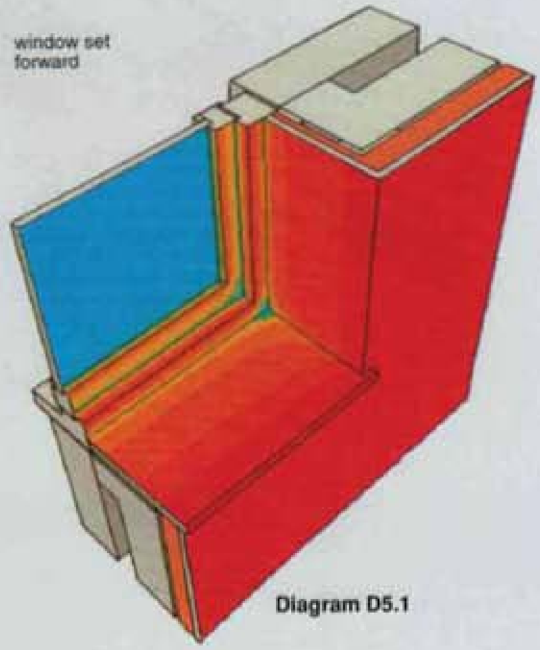


Diagram D5.1

SLIGHT RISK OF MOULD

The thermal analysis showed that insulating the reveal, as in Diagram **D5.1**, is sufficient to raise surface temperatures at the jamb above 13.5°C, even with the window forward.

SLIGHT RISK OF MOULD

Adding 10 mm of insulation below the sill, as in Diagram **D5.2**, raises surface temperatures further. However, there is still a mould growth risk in the corner where the window board and reveal meet the window frame.

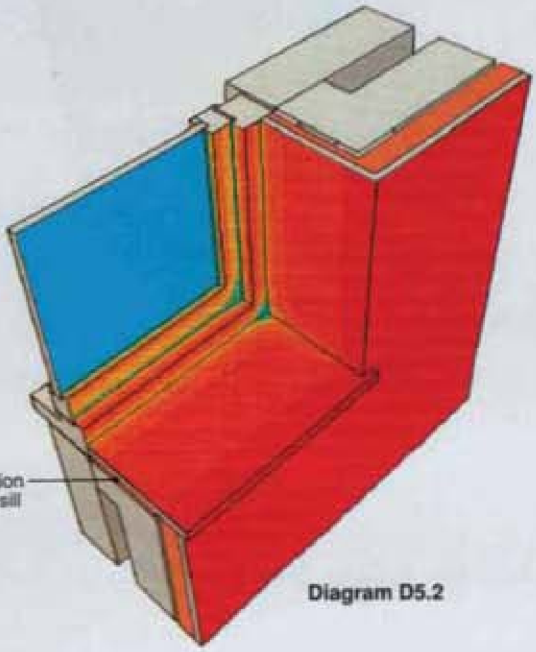


Diagram D5.2

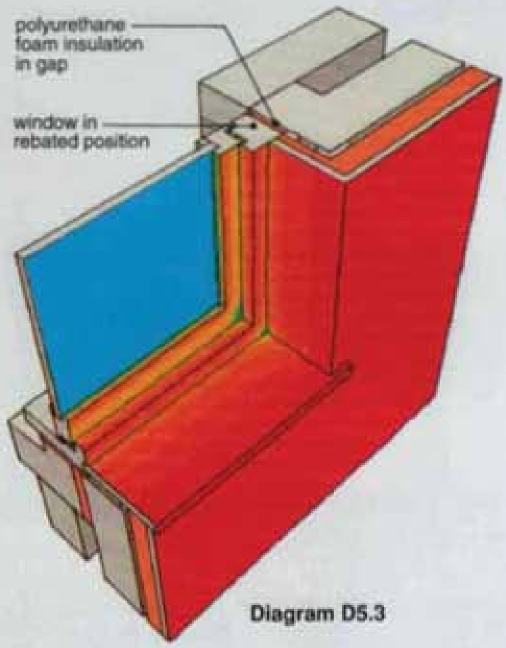


Diagram D5.3

SLIGHT RISK OF MOULD

Setting the window back in the rebated position, as in Diagram **D5.3**, raises surface temperatures marginally, but the slight risk of mould growth in the corner still persists. This detail assumes the window is fixed in a prepared opening and uses polyurethane foam to seal the 10 mm gap between the window frame and the opening. This risk is inherent with internal insulation.

The only certain way of raising all internal temperatures above 13.5°C is to position the window flush with the internal wall surface. However, this creates serious problems of detailing to avoid rain penetration.

E JAMB AND SILL – INSULATION BEHIND DPC

SLIGHT RISK OF MOULD

Adding insulation to the jamb and sill, as in Diagram **E5.1**, gives no significant improvement in surface temperatures compared with the full blockwork return shown in Diagram **D5.1**.

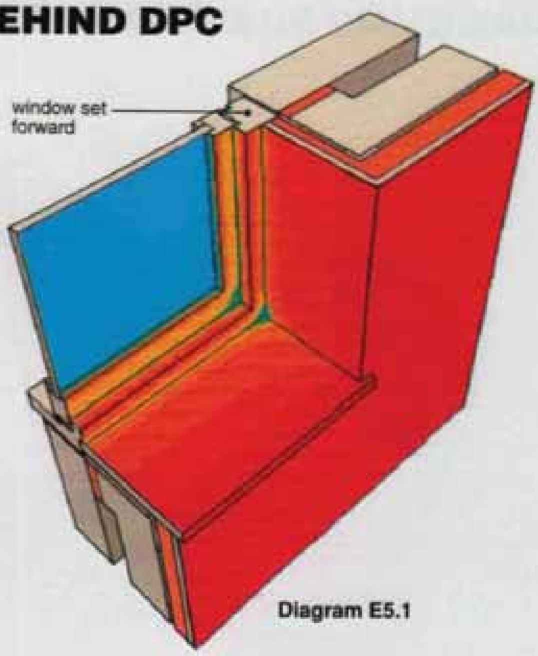


Diagram E5.1

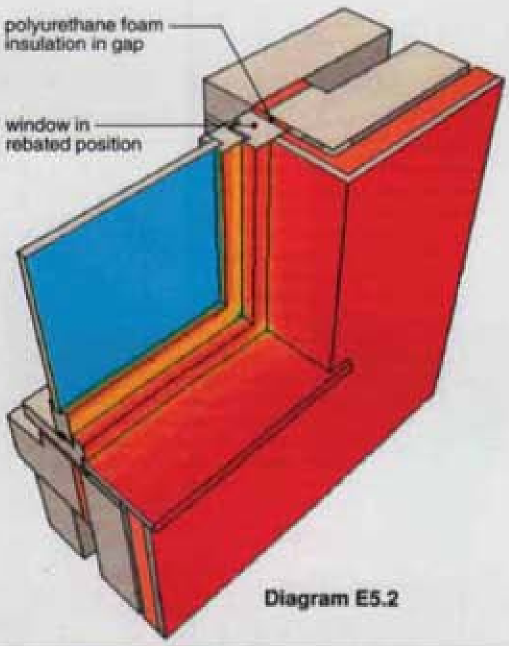


Diagram E5.2

SLIGHT RISK OF MOULD

The best results are achieved by setting the windows in the rebated position, as in Diagram **E5.2**. This detail assumes the window is fixed in a prepared opening and uses polyurethane foam to seal the 10 mm gap between the window frame and the opening. With this solution, the mould growth risk in the corner is almost eliminated.

F JAMB AND SILL – INSULATING CLOSER

SLIGHT RISK OF MOULD

Using an insulated cavity closer gives very similar results to those when insulation is placed behind the dpc, as for Junction E.

Setting the window back to lap the insulated closer fully, as in Diagram **F5.1**, eliminates a thermal bridge at the junction with the window frame, but a slight mould growth risk persists in the corner.

The insulated closer is a good solution because it can also be used to create an airtight seal between the window frame and wall.

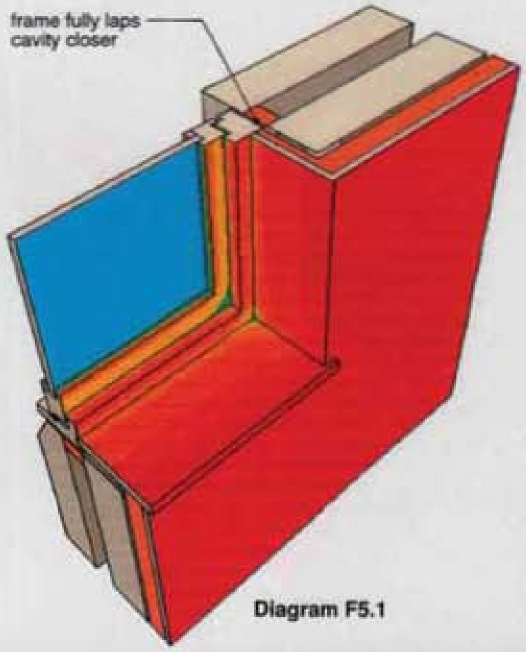


Diagram F5.1

G GABLE WALL – JUNCTION WITH CEILING

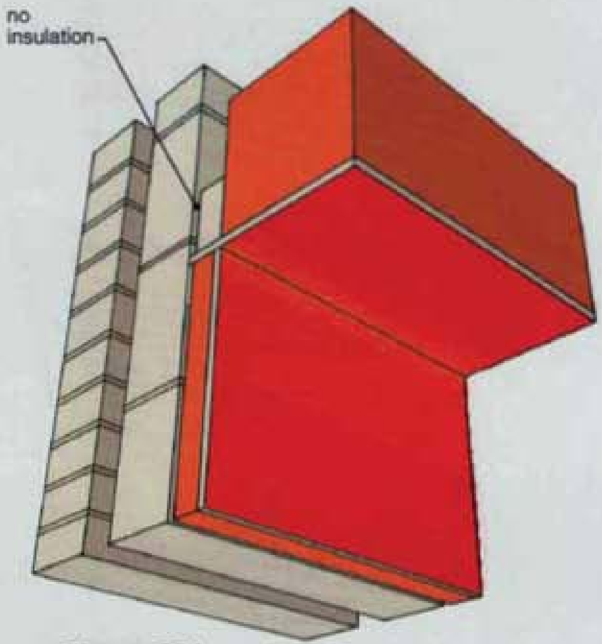


Diagram G5.1

MINOR THERMAL BRIDGE

Omitting insulation from between the last ceiling joist and the gable wall, as in Diagram **G5.1**, does not create a major thermal bridge.

BEST PRACTICE

Butting the insulation against the gable wall, as in Diagram **G5.2**, raises the temperature by about 1°C.

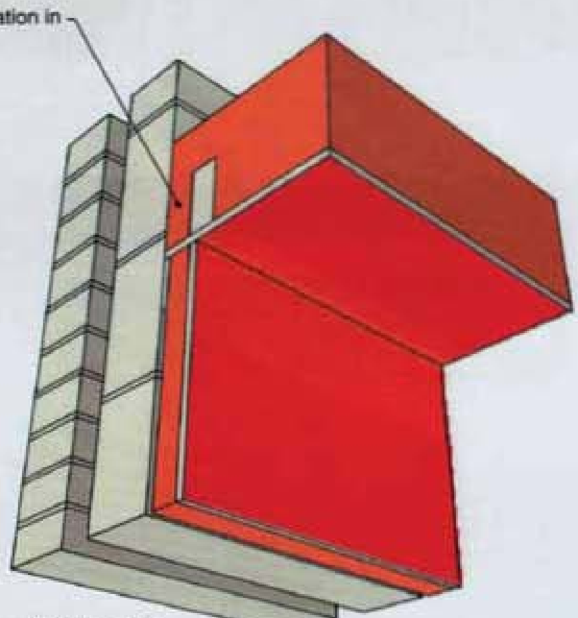


Diagram G5.2

H JUNCTION WITH INTERNAL PARTITION

MINOR THERMAL BRIDGE

Breaks in the internal insulation layer are inevitable at the junction between internal partitions and the external wall.

In Diagram **H5.1**, dense blockwork is used for both the inner leaf and the partition wall. The fall in temperature at the corner is more marked than in Diagram **H5.2**, but the wall surface is unlikely to cool to the point where mould growth would be a risk. However, Diagram **H5.1A** shows that the surface temperature of the blockwork at the junction of the partition and the external wall is up to 2°C colder than in Diagram **H5.2A**. This would increase the risk of interstitial condensation on the blockwork partition. To minimise this risk use insulating blockwork.

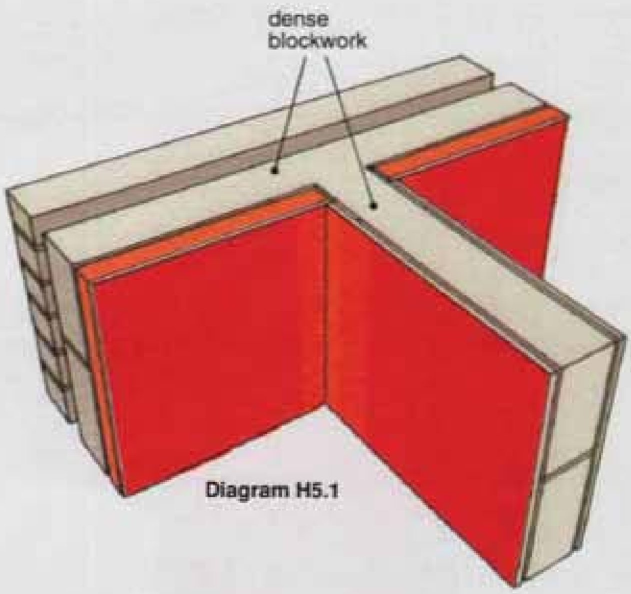


Diagram H5.1

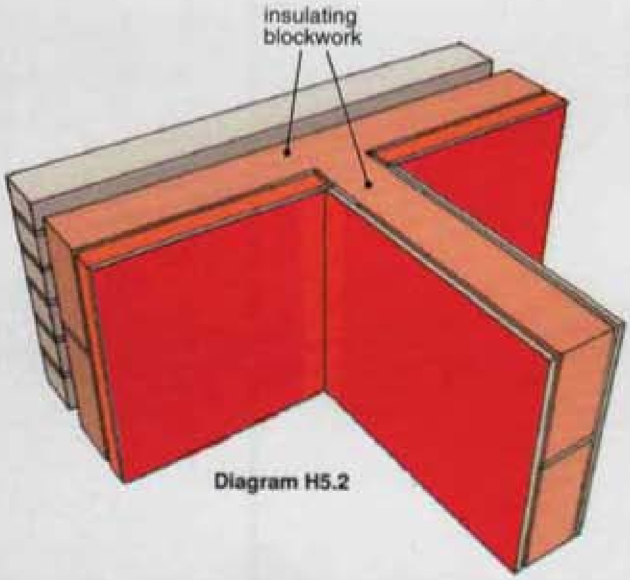


Diagram H5.2

BEST PRACTICE

In Diagram **H5.2**, insulating blockwork is used for the inner leaf and the partition wall. Diagram **H5.2A** shows the temperature scale through the construction.

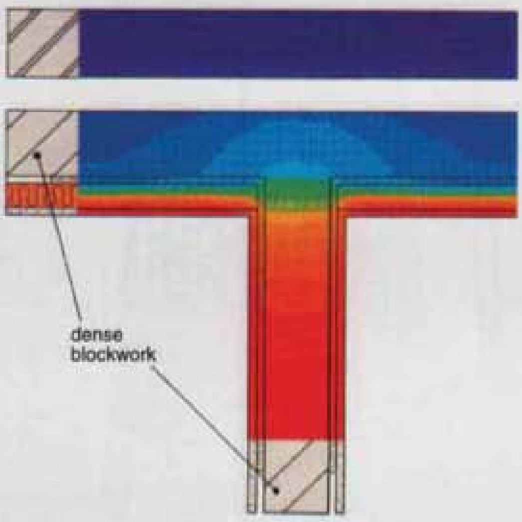


Diagram H5.1A

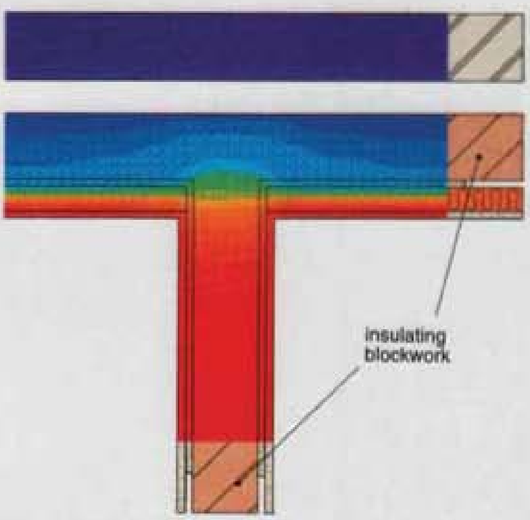
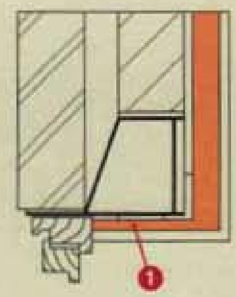


Diagram H5.2A

SUMMARY OF RECOMMENDATIONS AT WINDOW OPENINGS

Lintel details

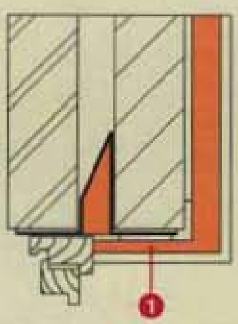
A Steel box lintel



Best Practice

1 The soffit should be insulated with internal insulation, at least 13 mm thick.

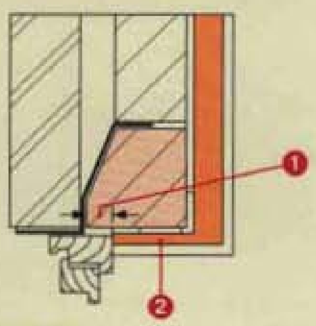
B Folded steel lintel



Best Practice

1 The soffit should be insulated with internal insulation at least 13 mm thick.

C Aircrete lintel



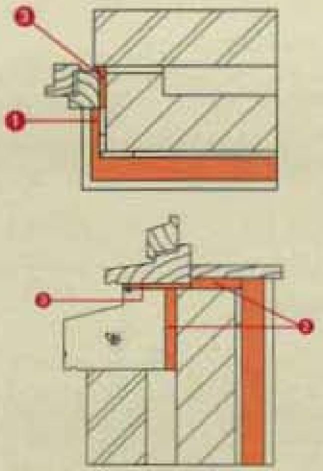
Best Practice

1 The window frame should be set back to lap aircrete lintel by at least 45 mm

2 The soffit should be insulated with internal insulation at least 13 mm thick.

Jamb and sill

D Blockwork returned



Minimum recommendations

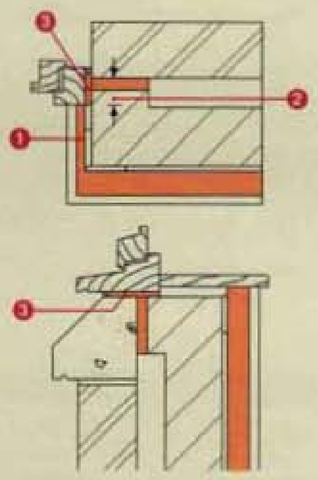
1 Insulate the reveal, AND

2 Insulate under the window board, or the back of the subsill (where the window is rebated), AND

3 Insulate between the window frame and the prepared opening.

None of the details tested avoided a small risk of mould growth at the corner between the reveal and the window board

E Insulation behind dpc



Minimum recommendations

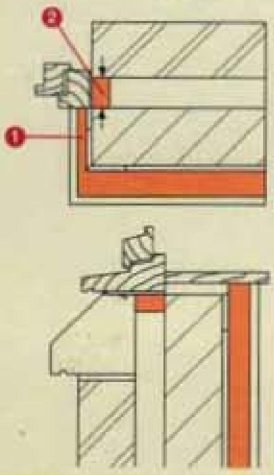
1 Insulate the reveal, AND

2 Set the window frame back at least 45 mm as shown, AND

3 Insulate between the window frame and the prepared opening.

None of the details tested avoided a small risk of mould growth at the corner between the reveal and the window board

F Insulating closer



Minimum recommendations

1 Insulate the reveal, AND

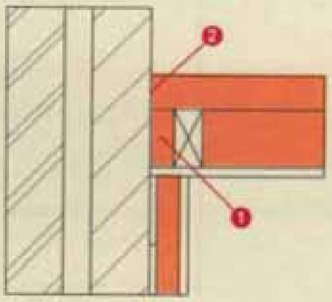
2 Set the window frame back at least 45 mm to lap the insulated closer.

None of the details tested avoided a small risk of mould growth at the corner between the reveal and the window board

Note: Internal insulation should include a vapour check on the warm side of the insulation.

SUMMARY OF RECOMMENDATIONS AT GABLE WALLS

G Gable wall – junction with ceiling

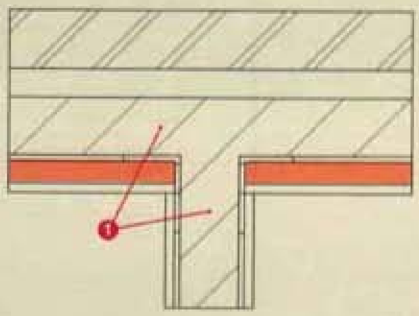


Best Practice

1 Insulate the gap between the last ceiling joist and the gable wall, AND

2 Butt the top layer of insulation against the gable wall.

H Junction with internal partition



Best Practice

1 Use insulating blockwork (maximum thermal conductivity of 0.3 W/m·K).

Note: Internal insulation should include a vapour check on the warm side of the insulation.

Ground bearing floors

Introduction
It is possible to insulate a ground bearing concrete floor by placing insulation either:

- above the slab (the examples use 50 mm polystyrene beadboard below 18 mm chipboard), or
- below the slab (the examples use 30 mm extruded polystyrene).

Both of these constructions achieve U-values of 0.45 W/m²K or less for a detached house and about 0.35 W/m²K or less for terraced housing.

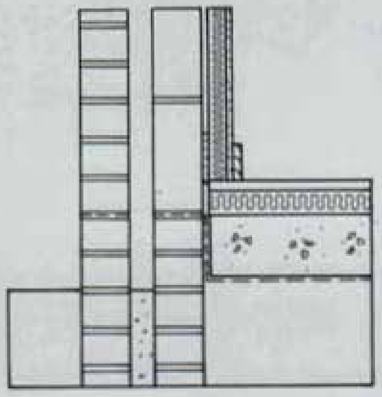
Generally, floors with insulation above the floor slab are warmer and easier to detail to avoid thermal bridging than floors with insulation below the floor slab. However, the preferred position for the floor insulation is likely to be governed by other factors, including:

- thermal mass
- the drying out time needed for any concrete and screed located above the dpc
- the need to accommodate services within the ground floor.

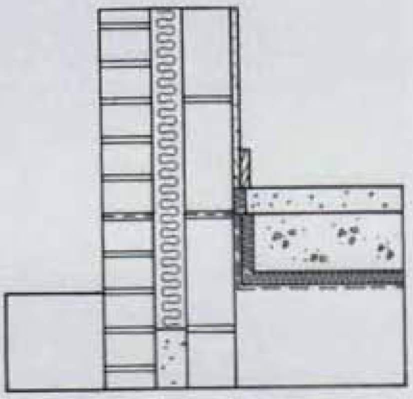
For example, the two constructions shown below contrast the thermal mass of:

- a cavity wall with internal insulation combined with floor insulation above the slab
- a cavity wall with cavity insulation combined with floor insulation below the slab.

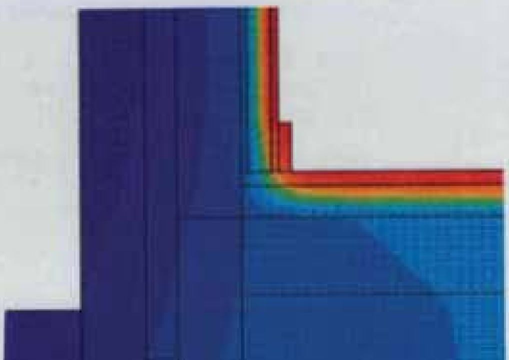
Both details avoid thermal bridging equally well, but would behave quite differently when subjected to intermittent heating in winter or solar gains in summer.



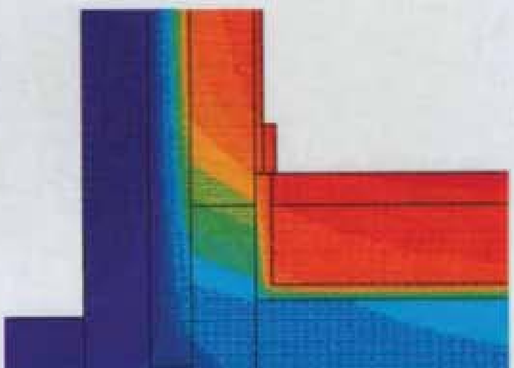
Construction detail



Construction detail



Construction with low thermal mass



Construction with high thermal mass

A CAVITY INSULATED WALL – INSULATION ABOVE SLAB

MINOR THERMAL BRIDGE

Diagram **A6.1** shows that there is only a minor thermal bridge with this construction. This is because brick is used for the inner leaf below dpc level.

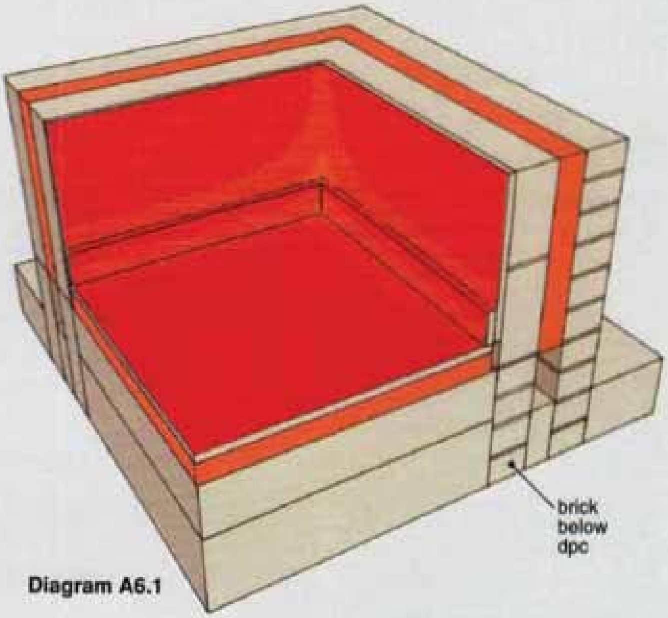


Diagram A6.1

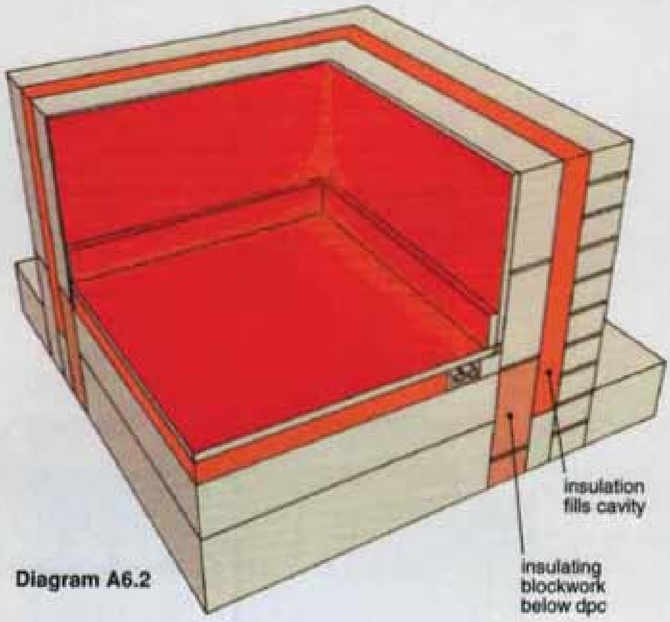


Diagram A6.2

MINOR THERMAL BRIDGE

Diagram **A6.2** shows the effect of removing a section of floor insulation to accommodate service pipes.

Starting the cavity insulation 150 mm below the dpc and using an insulating block below dpc raises surface temperatures. This detail could be further improved by insulating the service pipes in the floor.

B CAVITY INSULATED WALL – INSULATION BELOW SLAB

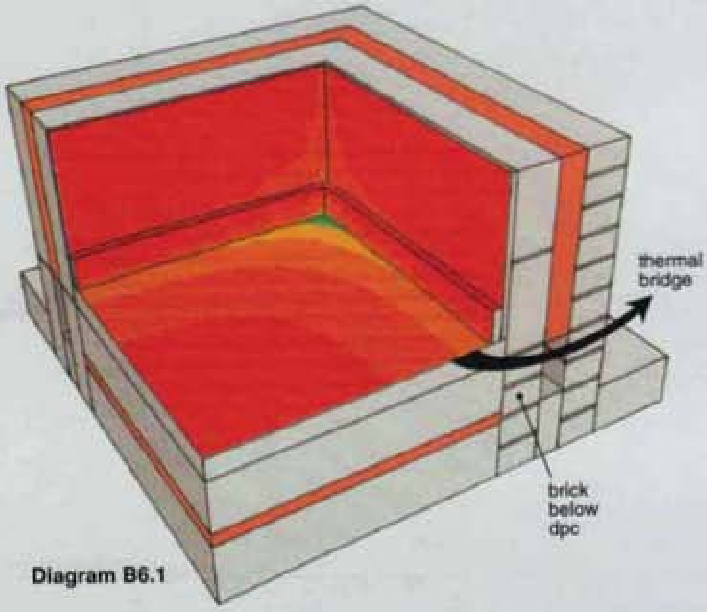


Diagram B6.1

RISK OF MOULD

Diagram **B6.1** shows a typical construction detail where both the wall and floor have U-values of 0.45 W/m²K. The break between wall and floor insulation, coupled with the use of brick below the dpc, creates an obvious thermal bridge, with a risk of mould growth in the corner.

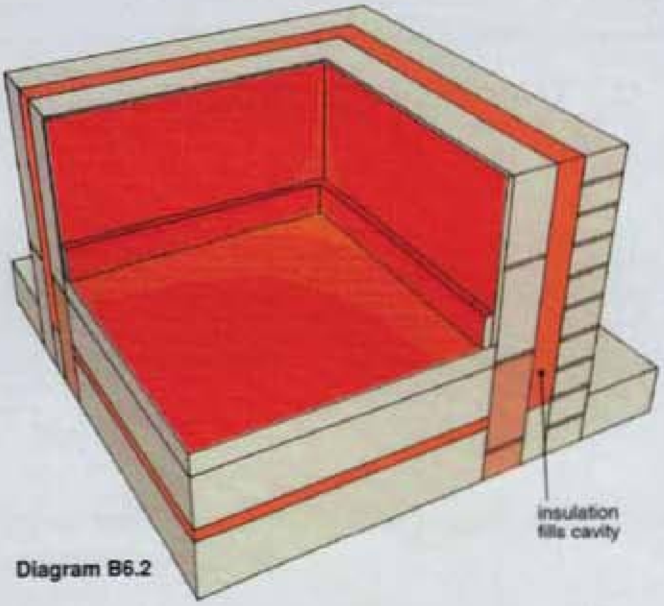


Diagram B6.2

MINOR THERMAL BRIDGE

In Diagram **B6.2** the cavity insulation is taken below dpc level. In addition, an insulating block is used below the dpc which raises the surface temperature in the corner and virtually eliminates the risk of mould growth.

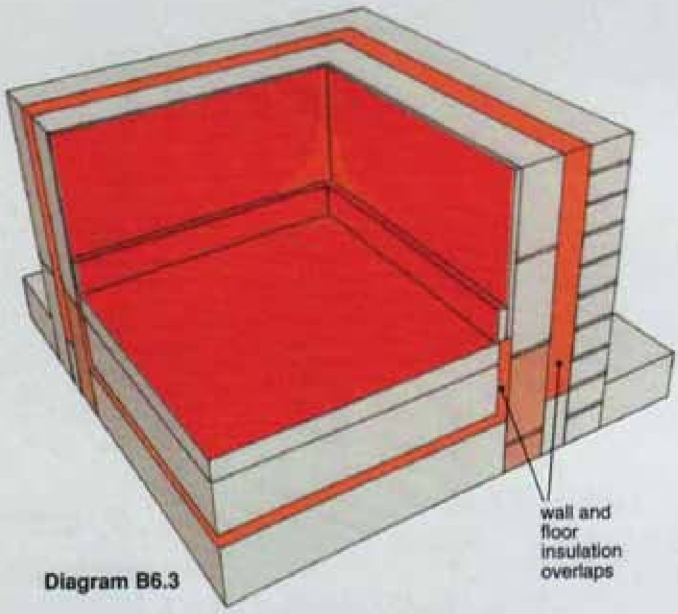


Diagram B6.3

BEST PRACTICE

The best results were achieved by 'overlapping' the wall and floor insulation, as in Diagram **B6.3**. This eliminated the thermal bridge, resulting in substantially higher surface temperatures in the corner.

C TIMBER FRAMED WALL – INSULATION ABOVE SLAB

BEST PRACTICE

With this form of construction, continuity between the wall and floor insulation is broken by the timber sole plate and wall framing. However, as can be seen from Diagram **C6.1**, the surface temperatures remain high enough to avoid problems of mould growth and condensation.

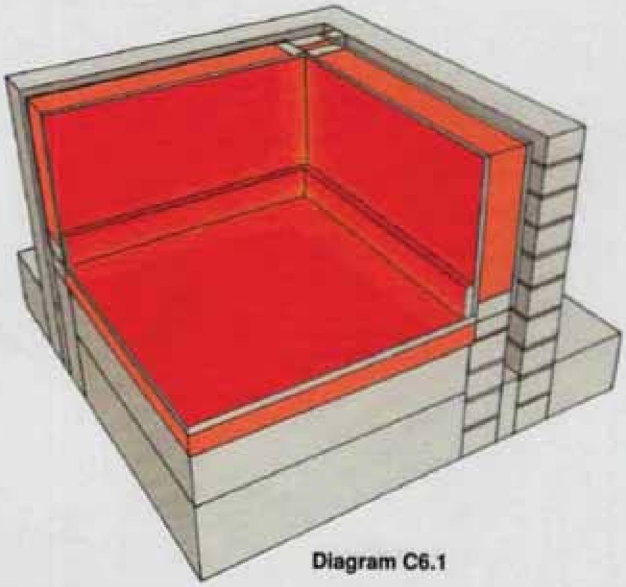


Diagram C6.1

D TIMBER FRAMED WALL – INSULATION BELOW SLAB

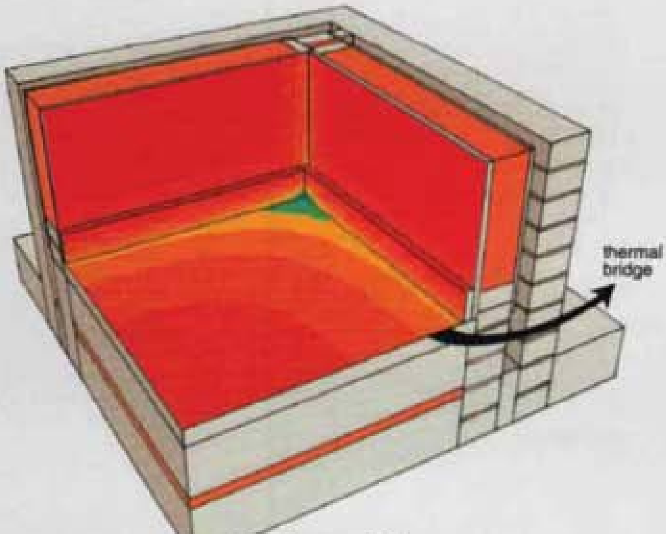


Diagram D6.1

RISK OF MOULD

A major thermal bridge exists where the floor insulation is not turned up at the edge of the slab, as in Diagram **D6.1**.

BEST PRACTICE

Where the floor insulation is turned up at the edge of the floor slab and insulating blockwork is used below the dpc, surface temperatures are significantly higher than in Diagram **D6.1**.

In addition, insulating the edge of the screed, as in Diagram **D6.2**, gives the best results. The interruption of the insulation by the timber framing is largely responsible for the slightly lower temperatures at the corner.

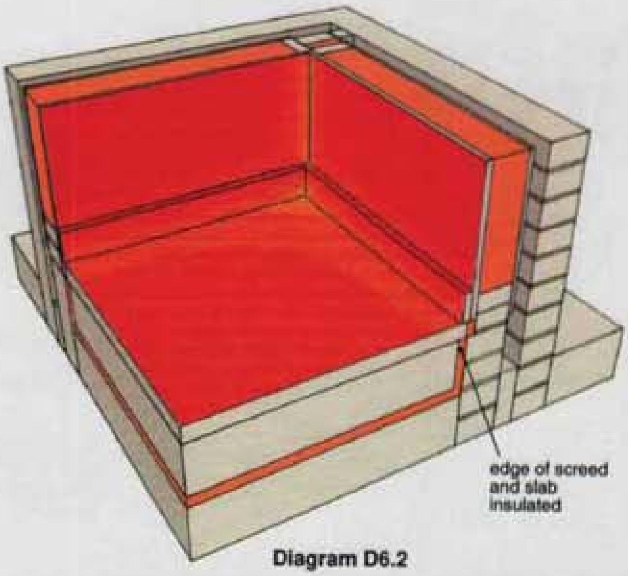


Diagram D6.2

E INTERNALLY INSULATED WALL – INSULATION ABOVE SLAB

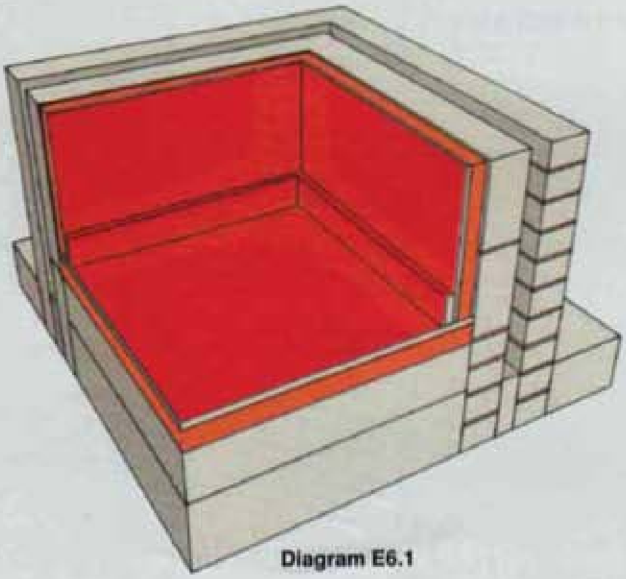


Diagram E6.1

BEST PRACTICE

The continuity of floor and wall insulation avoids thermal bridging problems. In this example, 50 mm expanded polystyrene insulation is used in the floor and 38 mm extruded polystyrene in the wall lining.

F INTERNALLY INSULATED WALL – INSULATION BELOW SLAB

MAJOR RISK OF MOULD

A major thermal bridge exists where there is a break between the wall and floor insulation, as shown in Diagram **F6.1**.

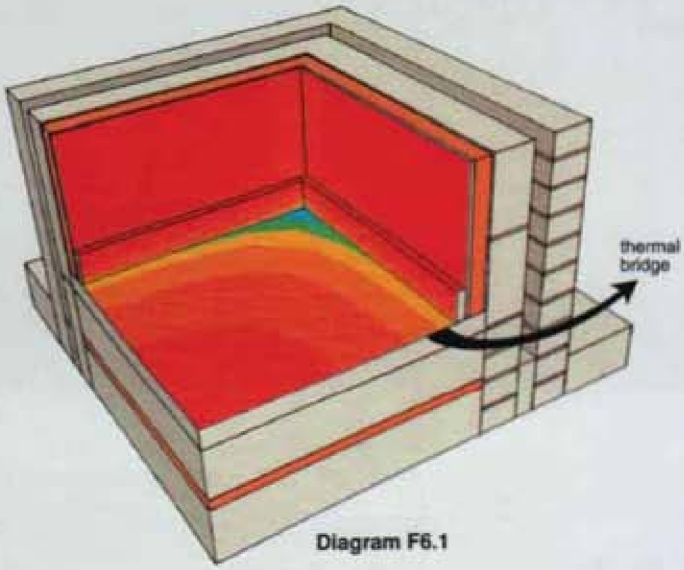


Diagram F6.1

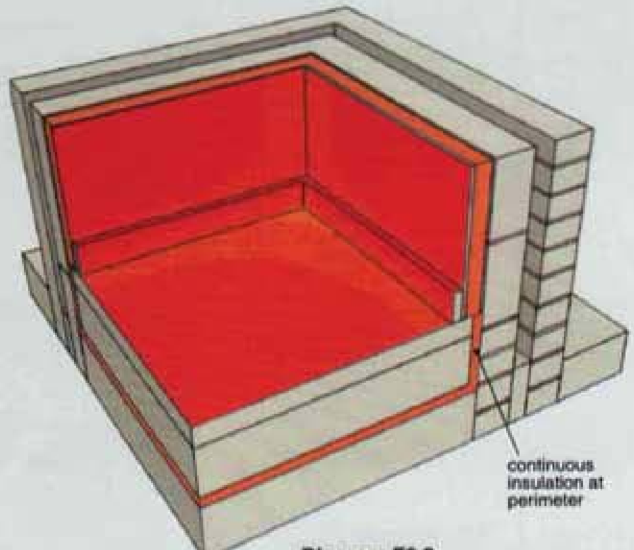
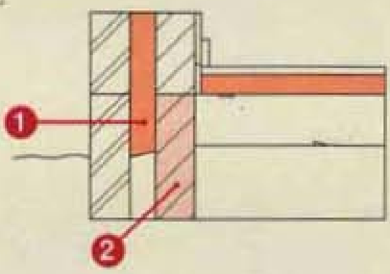
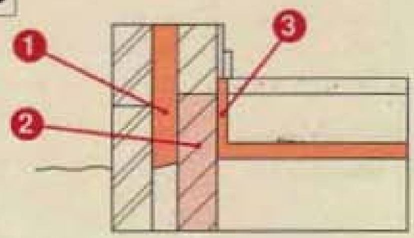
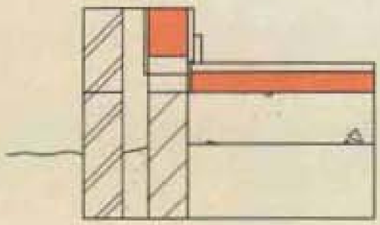
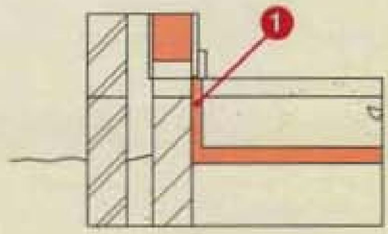
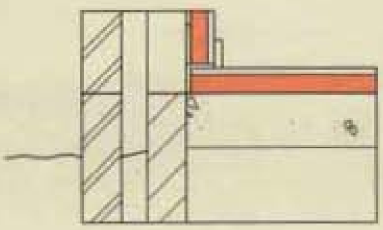
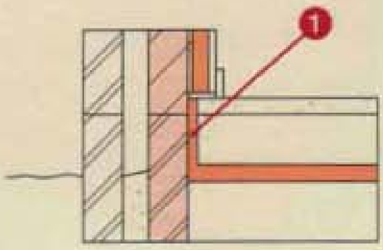


Diagram F6.2

BEST PRACTICE

Insulating the edge of the screed, as in Diagram **F6.2**, avoids a thermal bridge by ensuring continuity between the wall and floor insulation, even where brick is used below the dpc.

SUMMARY OF RECOMMENDATIONS

Wall construction	Floor insulation position	
	Above slab	**Below slab**
Cavity insulated wall	**A**  **Best Practice** **1** Start the cavity insulation a minimum 150 mm below finished slab level, AND **2** Use insulating blockwork below dpc level.	**B**  **Best Practice** **1** Start the cavity insulation a minimum 150 mm below finished slab level, AND **2** Use insulating blockwork below dpc level **3** Provide edge insulation to the slab and screed.
Timber framed wall	**C**  **Best Practice** The floor insulation abuts the timber framed wall.	**D**  **Best Practice** **1** Provide edge insulation to the slab and screed.
Internally insulated wall **Note:** Internal insulation should include a vapour check on the warm side of the insulation	**E**  **Best Practice** The floor and internal wall insulation are continuous.	**F**  **Best Practice** **1** Provide edge insulation to the slab and screed.

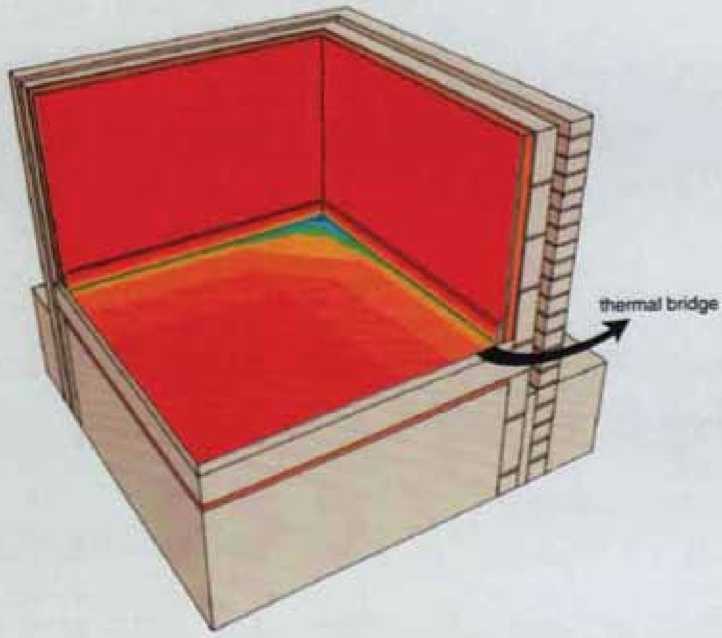
Raft foundations and suspended concrete ground floors

Introduction

This chapter examines thermal bridging for concrete raft foundations and suspended concrete ground floors. Both types of floor construction have common problems and solutions for avoiding thermal bridging.

Placing insulation above the floor was shown to have few thermal bridge problems. In contrast, where insulation was placed below the floor, thermal bridging could be serious enough to create a high risk of mould growth and condensation at the floor perimeter, particularly in the corners of rooms.

The illustration below shows an extreme example of a thermal bridge, despite both the wall and floor constructions each having a U-value of 0.45 W/m²K.



A serious risk of mould growth can occur even where walls and floor have U-values of 0.45 W/m²K

A CAVITY INSULATED WALL – INSULATION ABOVE RAFT FOUNDATION

MINOR THERMAL BRIDGE

With the cavity insulation carried down 150 mm below the top surface of the concrete raft, as in Diagram **A7.1**, surface temperatures are relatively high with little risk of condensation.

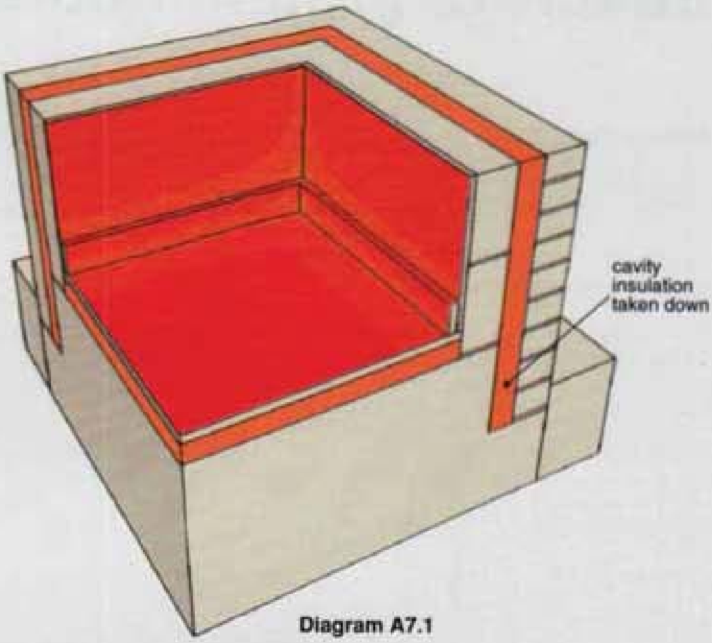


Diagram A7.1

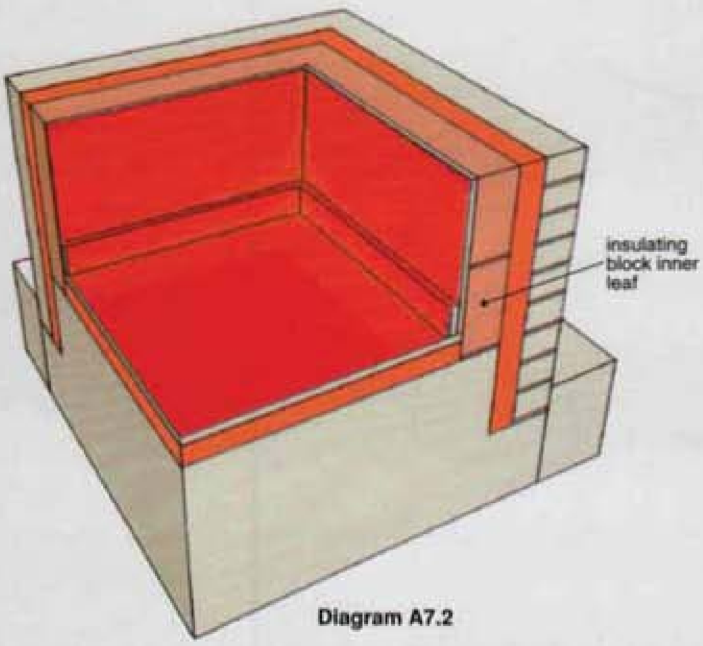


Diagram A7.2

BEST PRACTICE

Using an insulating block for the inner leaf, as in Diagram **A7.2**, increases the surface temperature at the corner by about 0.5°C.

B CAVITY INSULATED WALL – INSULATION BELOW SLAB

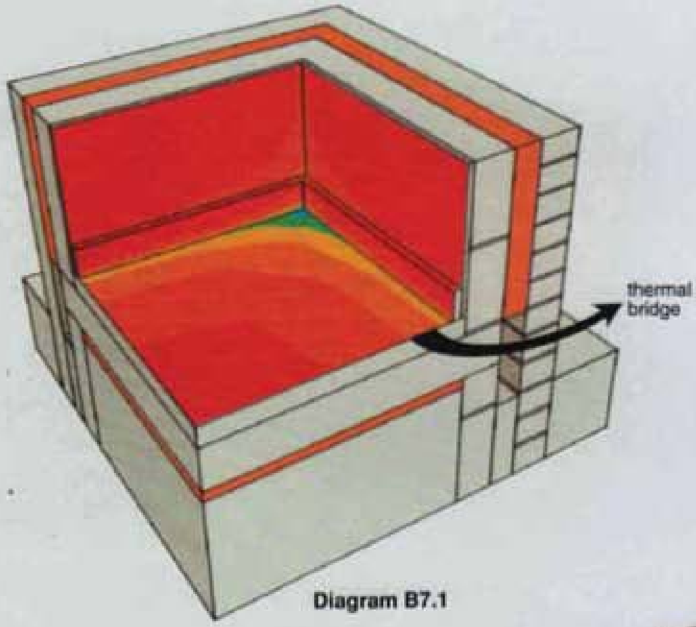


Diagram B7.1

MAJOR RISK OF MOULD

Although the wall and ground floor U-values in Diagram **B7.1** are 0.45 W/m²K, there is a thermal bridge between the wall and floor insulation. This is serious enough for there to be a major risk of mould growth at the corner of the floor slab.

SLIGHT RISK OF MOULD

Taking the cavity insulation down to lap the floor insulation, as in Diagram **B7.2**, raises the temperature at the base of the skirting board noticeably. However, brickwork or medium density blockwork in the inner leaf below the slab still forms a thermal bridge.

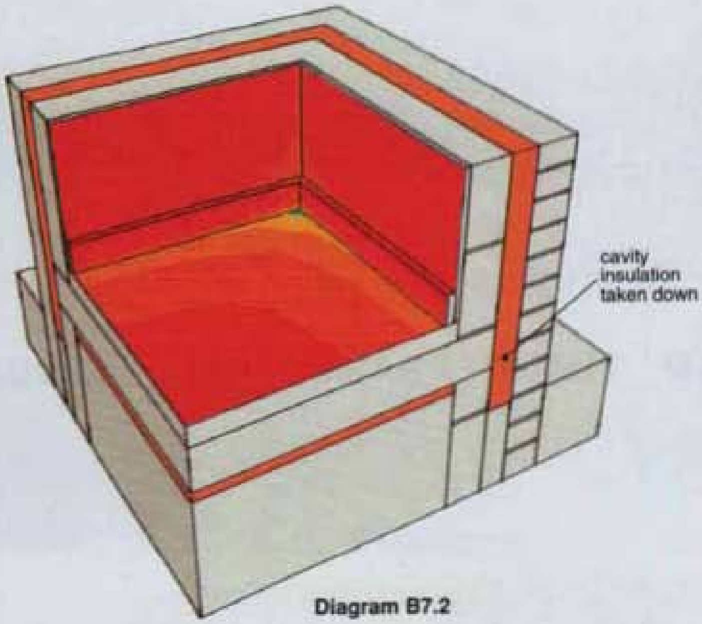


Diagram B7.2

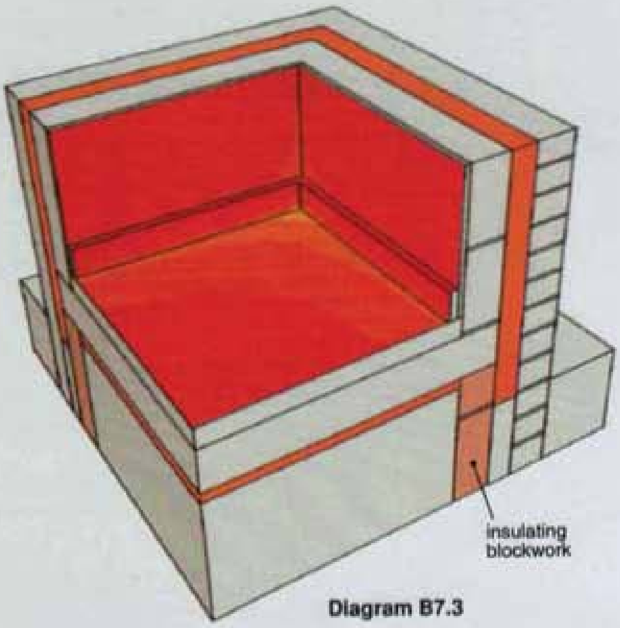


Diagram B7.3

THERMAL BRIDGE

Using an insulating block below the slab, as in Diagram **B7.3**, raises temperatures further, and gives the best results with this form of construction. However, surface temperatures are lower than if insulation was placed above the slab, as in Diagram **A7.2**.

Note. Standard insulating blocks with a compressive strength of 3.5 N/mm² are normally adequate for two-storey domestic construction. However, most manufacturers of insulating blocks also produce 7 N/mm² insulating blocks for use in the foundations of three-storey constructions, or wherever extra strength is needed.

C TIMBER FRAMED WALL – INSULATION ABOVE RAFT FOUNDATION

BEST PRACTICE

Diagram **C7.1** shows that there are no problems with this form of construction. The lower surface temperatures in the corner and at skirting level are largely due to the increased surface area for heat loss and the timber studding.

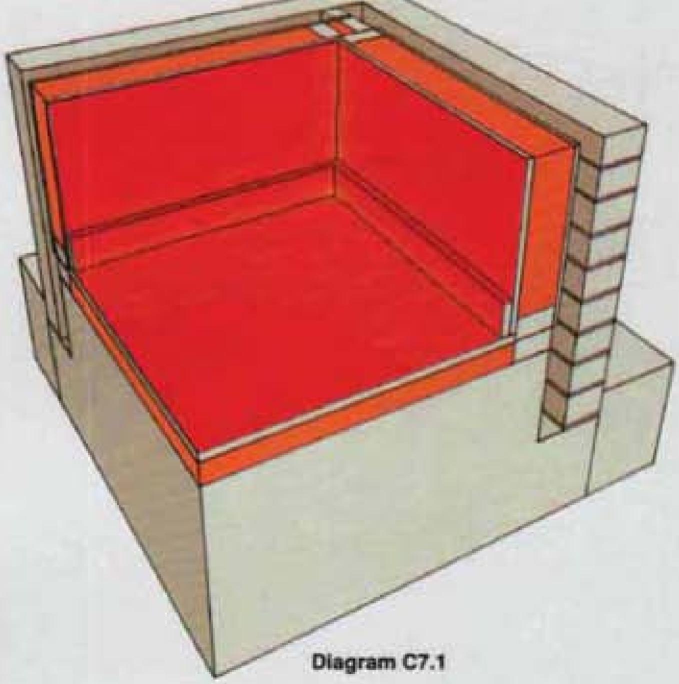


Diagram C7.1

D TIMBER FRAMED WALL – INSULATION BELOW SLAB

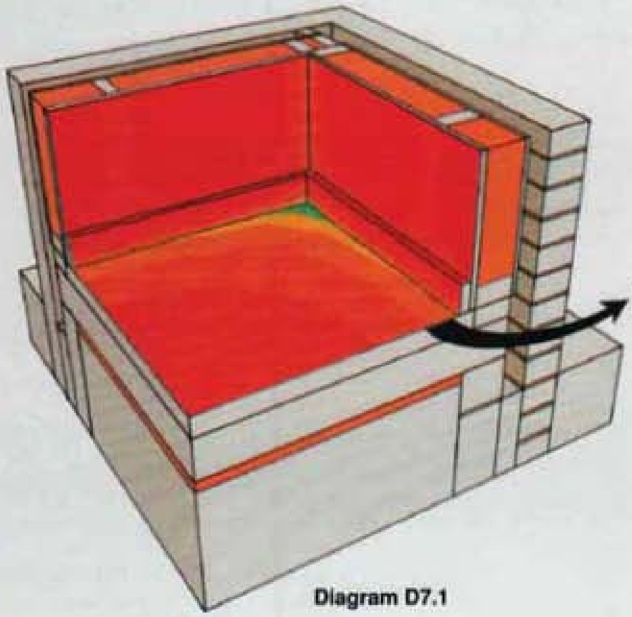


Diagram D7.1

RISK OF MOULD

Diagram **D7.1** shows that the thermal bridge between the wall and floor insulation is serious enough for there to be a risk of mould growth at the corner of the floor slab.

Avoiding the thermal bridge by inserting insulation in the cavity at floor level presents detailing problems. Where the walls are of timber framed construction, it would be preferable to position the floor insulation above the slab, as in Diagram **C7.1**.

E INTERNALLY INSULATED WALL – INSULATION ABOVE RAFT FOUNDATION

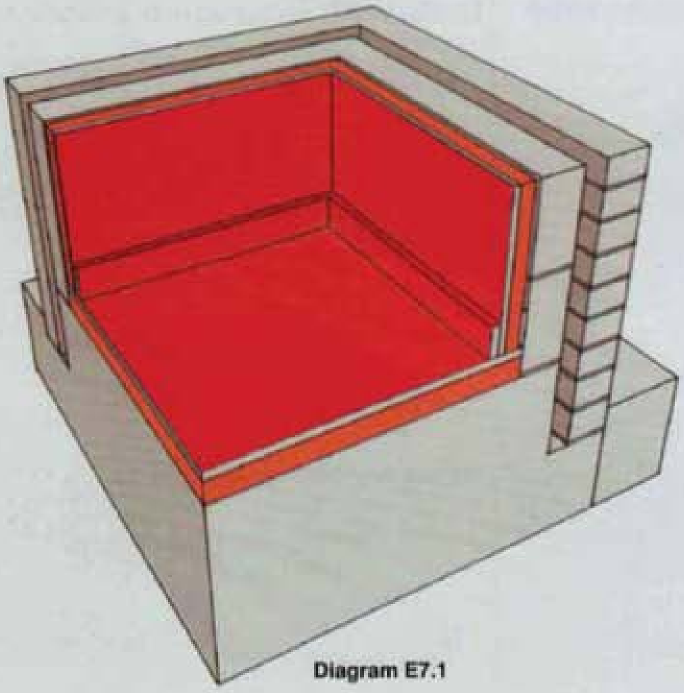


Diagram E7.1

BEST PRACTICE

Diagram **E7.1** shows that there are no problems with this form of construction. The wall and floor insulation are virtually continuous.

F INTERNALLY INSULATED WALL – INSULATION BELOW SLAB

MAJOR RISK OF MOULD

The unavoidable thermal bridge between the wall and floor insulation in Diagram **F7.1** results in a serious risk of condensation and mould growth at the corner of the slab. The floor insulation should be placed above the slab, as in Diagram **E7.1**.

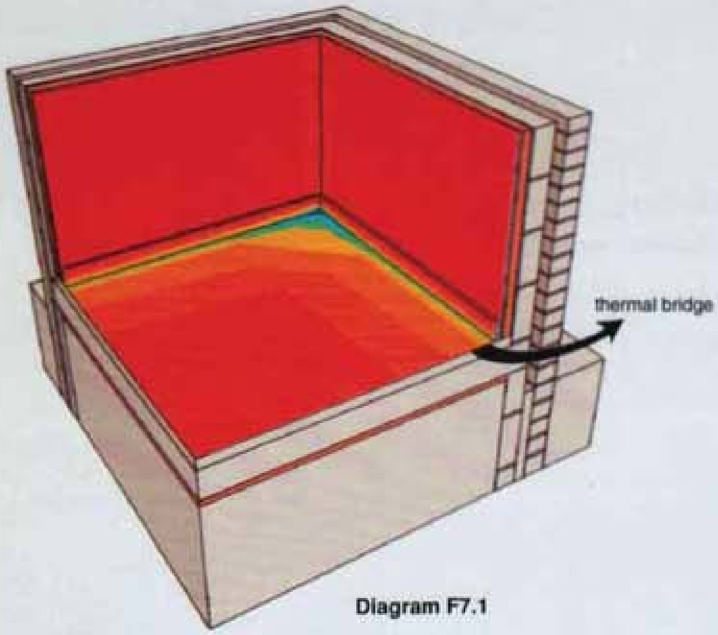
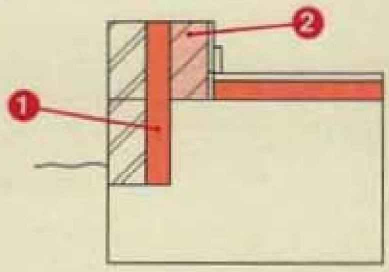
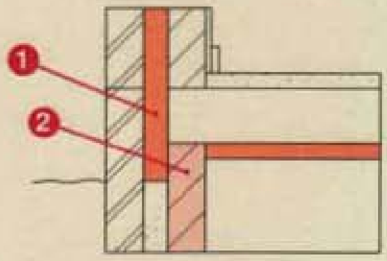
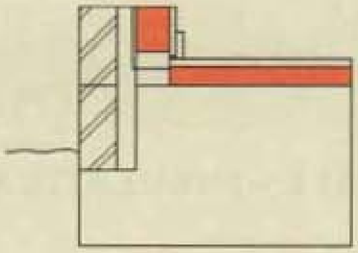
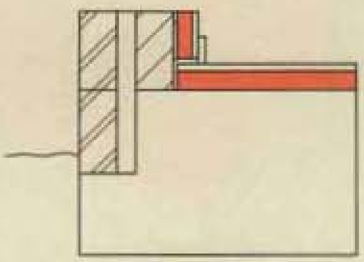


Diagram F7.1

SUMMARY OF RECOMMENDATIONS

Wall construction	Raft foundation with insulation above concrete	Suspended concrete ground floor with insulation below slab
Cavity insulated wall	**A**  **Best Practice** 1 Start the cavity insulation from the base of the cavity, AND 2 Use an insulating block for the inner leaf.	**B**  **Minimum recommendations** 1 Start the cavity insulation a minimum 225 mm below the finish slab level, AND 2 Use an insulating block below the slab.
Timber framed wall	**C**  **Best Practice** The floor insulation abuts the timber framed wall.	**D** **Diagram D7.1 on page 50 is not recommended.** **Consider an alternative solution.**
Internally insulated wall **Note:** Internal insulation should include a vapour check on the warm side of the insulation	**E**  **Best Practice** The floor and internal wall insulation are continuous.	**F** **Diagram F7.1 on page 51 is not recommended.** **Consider an alternative solution.**

Note: 'Minimum recommendations' provide advice on reducing the risk of mould growth occuring.

Precast concrete ground floors

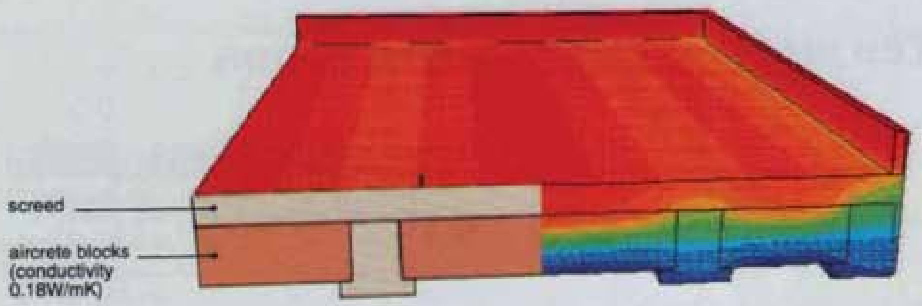
Introduction
There are two widely used methods for insulating beam and block ground floors:

- laying a continuous layer of insulation above the floor
- using insulating blocks between the precast beams.

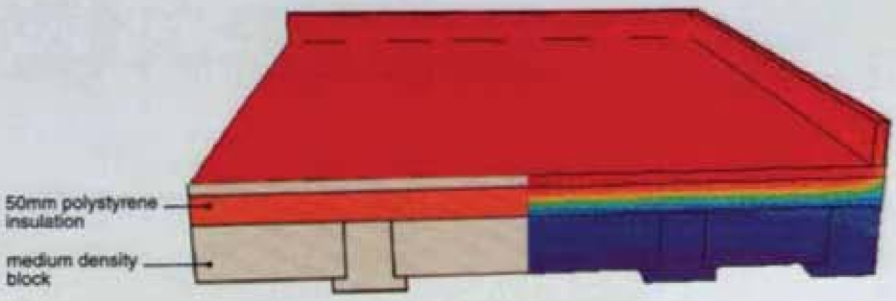
The results show that placing a layer of insulation above the precast floor is a good way of avoiding thermal bridging problems. The examples in this chapter use 50 mm thick polystyrene beadboard with an 18 mm chipboard finish. Although the polystyrene is shown laid directly on the beam and block floor, it is often necessary to lay a levelling screed to provide a sufficiently even surface for the polystyrene.

Using insulating blocks in the floor as the sole means of floor insulation proved to be insufficient to avoid the risk of mould growth. The thermal bridging through the dense precast concrete beams was a major heat loss path and presented a serious risk of mould growth where the beam abutted the external wall.

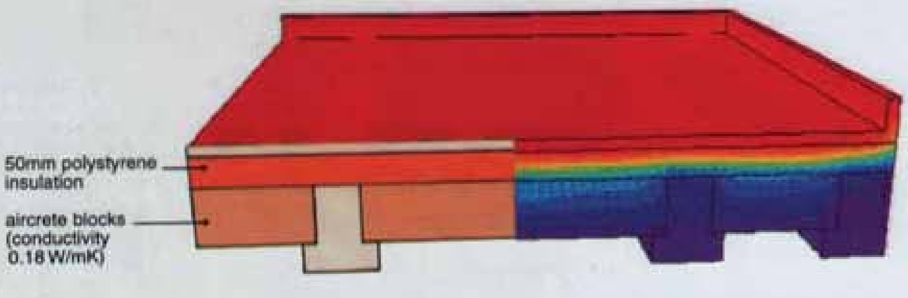
However, combining insulation above the floor with insulating blocks between the beams not surprisingly gave the best results. The examples below illustrate the effect of the dense concrete beams within the floor.



Screed finish with insulating blocks between beams



Full floor insulation



Full floor insulation with insulating blocks between beams

A CAVITY INSULATED WALL – INSULATION ABOVE FLOOR

BEST PRACTICE

There is no significant thermal bridge with this form of construction. The weak link is the use of a medium density block for the inner leaf as shown in Diagram **A8.1**. The thermal analysis showed that changing this to an insulating block raises the minimum temperature in the corner by 0.3°C.

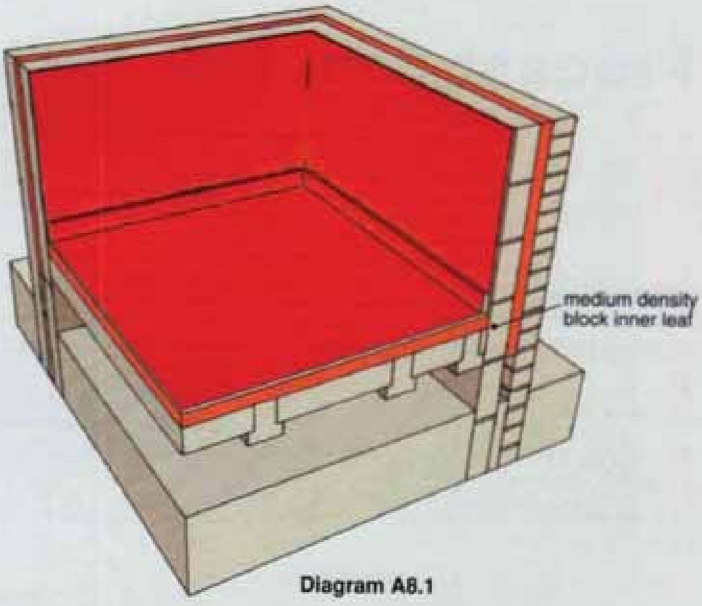


Diagram A8.1

B CAVITY INSULATED WALL – INSULATION IN FLOOR

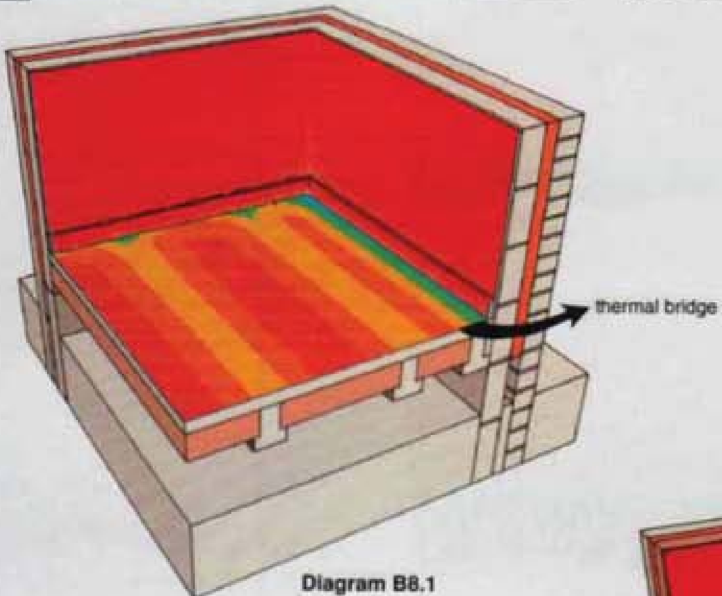


Diagram B8.1

RISK OF MOULD

The pattern of surface temperatures in Diagram **B8.1** clearly reflects the difference in the thermal conductivity between the dense concrete floor beams and the infill aircrete blocks. The thermal analysis showed that the main area of the floor is kept above 13.5°C and is unlikely to suffer from mould growth. However, there is a risk of mould growth occurring at the floor perimeter, especially where the dense concrete beam abuts the inner leaf.

SLIGHT RISK OF MOULD

Building the insulating floor blocks into the inner leaf, as shown in Diagram **B8.2**, greatly reduces the risk of mould growth. However, there is still a slight risk of mould growth at the ends of the dense concrete floor beams.

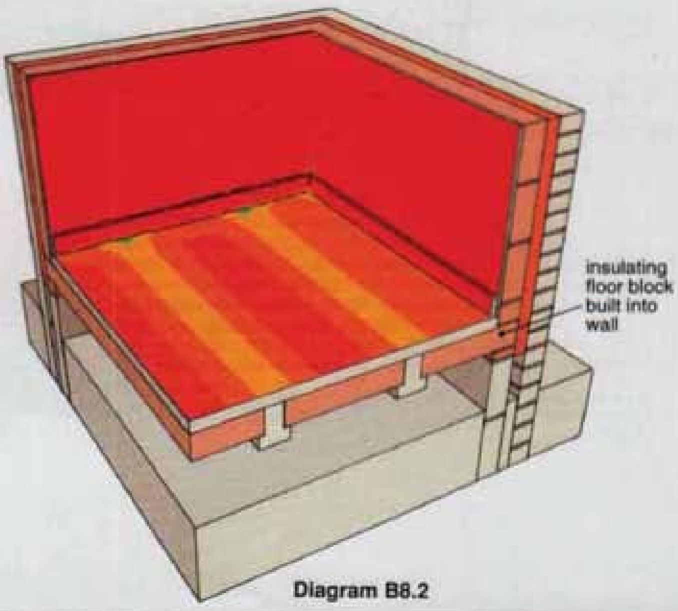


Diagram B8.2

C TIMBER FRAMED WALL – INSULATION ABOVE FLOOR

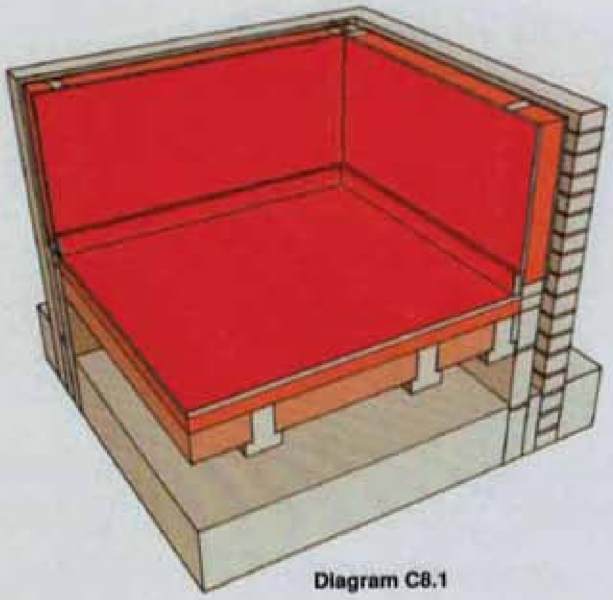


Diagram C8.1

BEST PRACTICE

There are no thermal bridge problems with this form of construction. Aircrete blocks have been used between the floor beams in this example. This explains the higher floor surface temperatures compared to Diagrams **A8.1** and **E8.1**. The pattern of timber studs and concrete beams is clearly visible from the surface temperatures.

D TIMBER FRAMED WALL – INSULATION IN FLOOR

MAJOR RISK OF MOULD

The temperatures at the floor perimeter are low enough for there to be a major risk of mould growth and condensation. This type of construction is not recommended. Insulation should be used above the beam and block floor, as in Diagram **C8.1**.

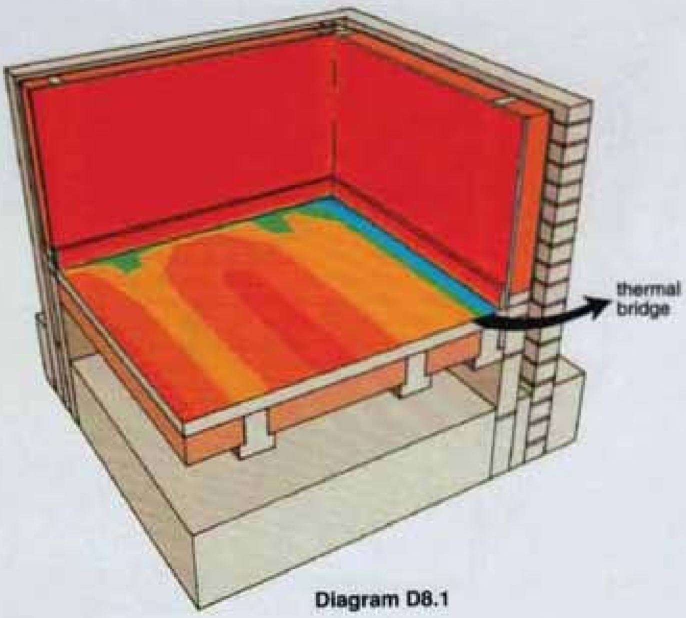


Diagram D8.1

E INTERNALLY INSULATED WALL – INSULATION ABOVE FLOOR

BEST PRACTICE

The continuity between floor and wall insulation means there are no thermal bridge problems with this construction.

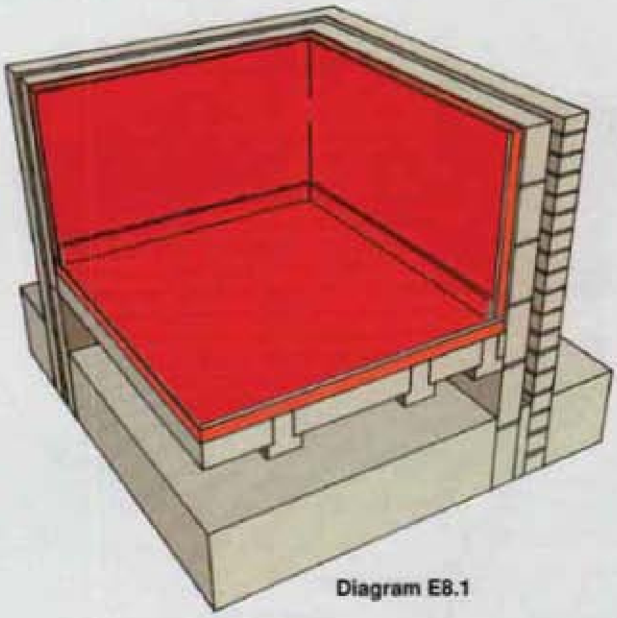


Diagram E8.1

F INTERNALLY INSULATED WALL – AIRCRETE BLOCKS IN FLOOR

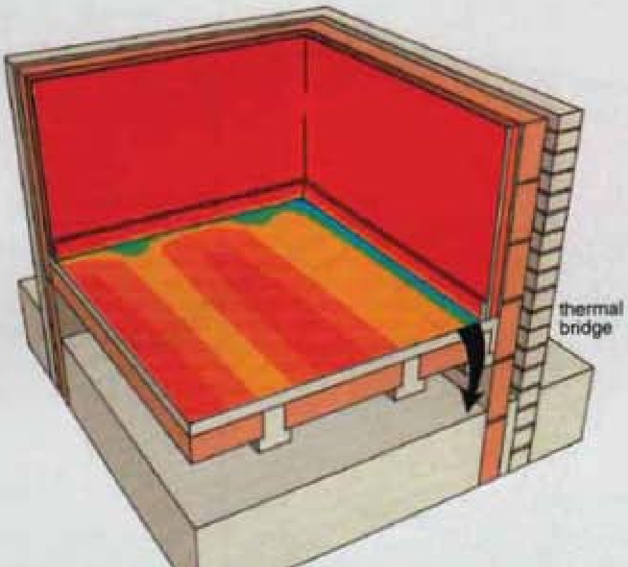
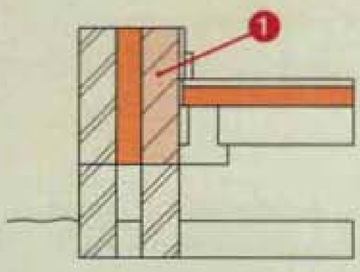
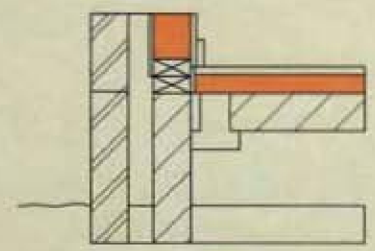
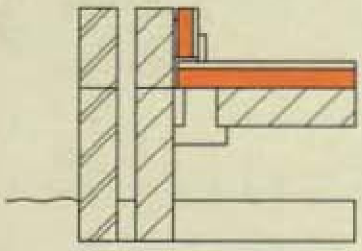


Diagram F8.1

MAJOR RISK OF MOULD

There is a high risk of mould growth at the floor perimeter with this construction. This type of construction is not recommended. Insulation should be used above the beam and block floor, as in Diagram **E8.1**.

SUMMARY OF RECOMMENDATIONS

Wall construction	Floor insulation position: Above slab	Floor insulation position: In floor
Cavity insulated wall	**A**  **Best Practice** **1** Use an insulating block for the inner leaf.	**B** **Diagrams B8.1 and B8.2 on page 54 are not recommended** **Consider an alternative solution.**
Timber framed wall	**C**  **Best Practice** The floor insulation abuts the timber framed wall.	**D** **Diagram D8.1 on page 55 is not recommended** **Consider an alternative solution.**
Internally insulated wall **Note:** Internal insulation should include a vapour check on the warm side of the insulation	**E**  **Best Practice** The floor and internal wall insulation are continuous.	**F** **Diagram F8.1 on page 56 is not recommended** **Consider an alternative solution.**

CHAPTER

9

Suspended timber ground floors

Introduction

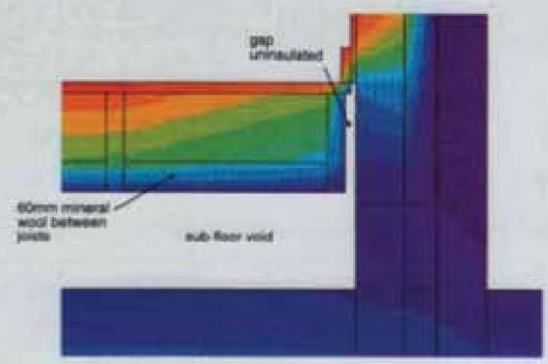
Timber ground floors can be readily insulated by placing insulation between the joists. Mineral wool quilts and slabs as well as rigid boards of foamed plastics can be used. The examples in this chapter use 60 mm thick mineral wool slabs. This would achieve a U-value of about 0.35 W/m²K for a detached house and about 0.3 W/m²K for a terraced house.

In most examples, the insulation is shown level with the underside of the floor joists, where it can be supported on netting stapled to the underside of the joists. This allows most pipes and cables to be located on the warm side of the insulation. (Note: where cables are placed on the warm side of the insulation reference should be made to the Institution of Electrical Engineers 'Regulations for electrical installations' to ensure heat is dissipated adequately.) However, when fitting the insulation around herring bone strutting, care is needed to ensure that there are no gaps that will allow air to bypass the insulation and chill the warm air space above.

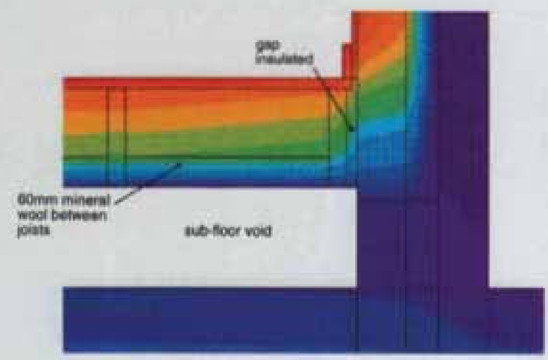
Placing the insulation directly below the floor deck gives marginally warmer surface temperatures at the floor perimeter compared to placing the insulation level with the underside of the floor joists.

With suspended timber ground floors it is essential to ventilate the sub-floor in accordance with Approved Document C. The airbrick in the inner leaf that supplies the sub-floor ventilation should be located **below** the insulation. In practice this can be achieved using a 'stepped' ventilator.

The examples given below highlight the importance of insulating the gap between the last floor joist and the inner leaf.



Gap between last joist and wall uninsulated



Gap between last joist and wall insulated

A JUNCTION WITH CAVITY INSULATED WALL

RISK OF MOULD

Placing 60 mm of mineral wool between the joists raises the surface temperature of the floor considerably compared with an uninsulated floor. However, as can be seen in Diagram **A9.1**, a thermal bridge does exist where insulation is omitted from the gap between the last joist and the wall. The thermal bridge is small, but serious enough for there to be a risk of mould growth.

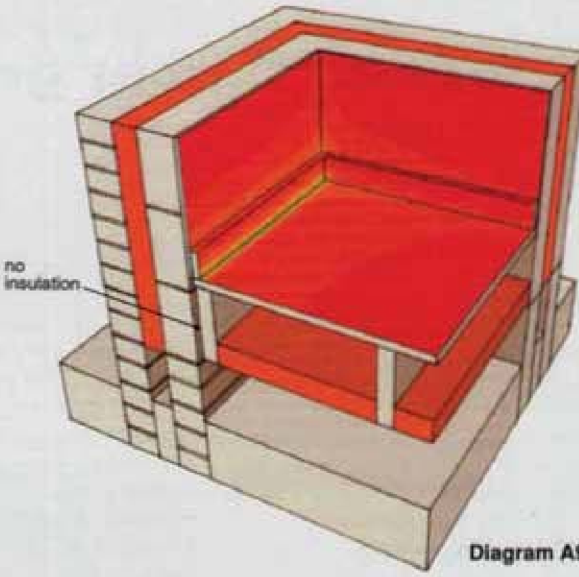


Diagram A9.1

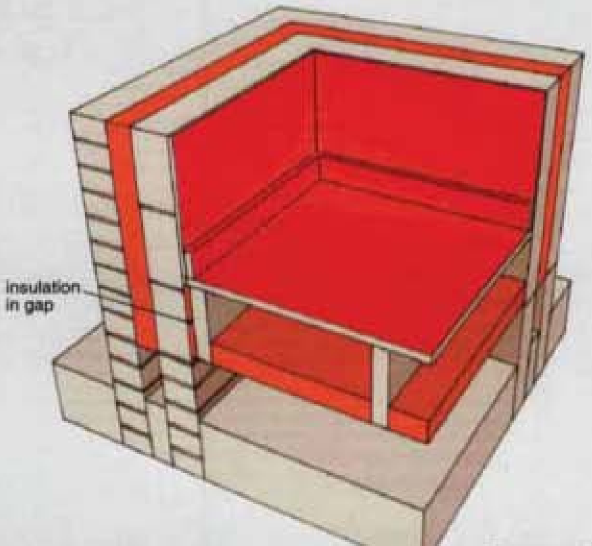


Diagram A9.2

BEST PRACTICE

Placing insulation in the gap between the last joist and the wall, as shown in Diagram **A9.2**, eliminates a thermal bridge at the skirting.

In timber floors, air infiltration between the skirting and the floor decking is often a more serious problem than thermal bridging. Placing mineral wool insulation in the gap directly below the skirting helps to reduce air infiltration.

B JUNCTION WITH TIMBER FRAMED WALL

BEST PRACTICE

The combination of a timber ground floor and timber framed wall does not result in any thermal bridging problems, as can be seen in Diagram **B9.1**.

The lower surface temperatures in room corners are largely due to the room geometry. The interruption of the insulation by timber members at this point and at skirting level, also contributes to the lower surface temperatures in these areas.

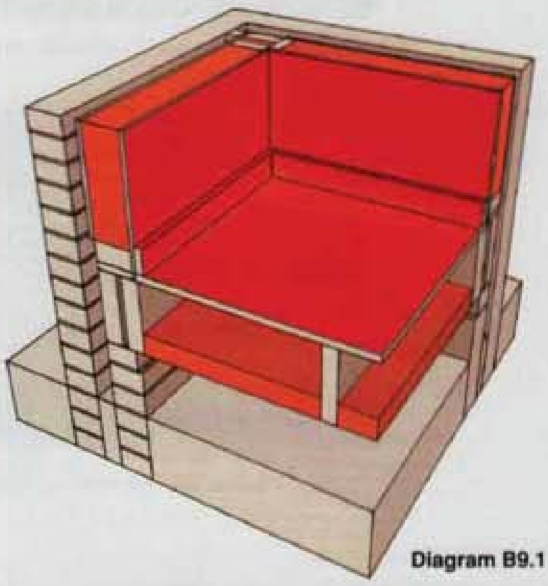


Diagram B9.1

C JUNCTION WITH INTERNALLY INSULATED WALL

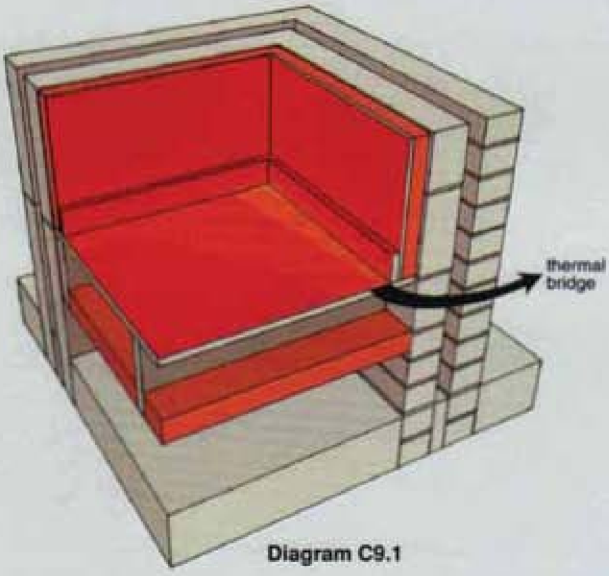


Diagram C9.1

THERMAL BRIDGE

In Diagram **C9.1** the gap between the last joist and the wall is insulated as in Diagram **A9.2**. The lowest surface temperatures occur as a result of the break between the wall and floor insulation. In Diagram **C9.1**, brickwork is used below dpc level.

BEST PRACTICE

To avoid the thermal bridge shown in Diagram **C9.1**, the insulating quilt in the floor should be turned up at the junction with the wall, as in Diagram **C9.2**.

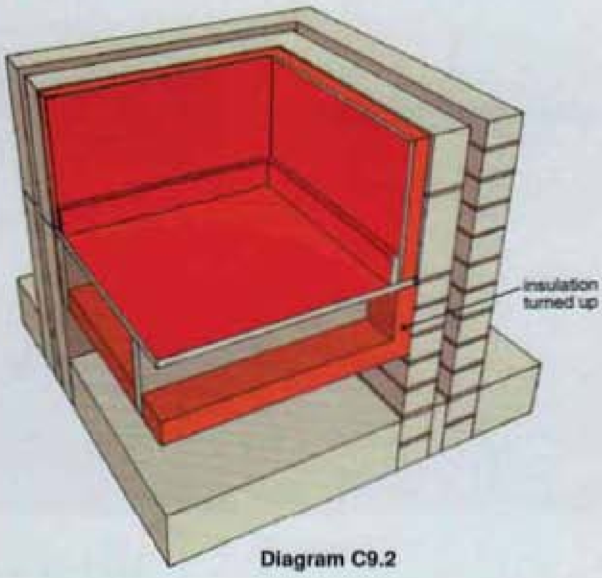


Diagram C9.2

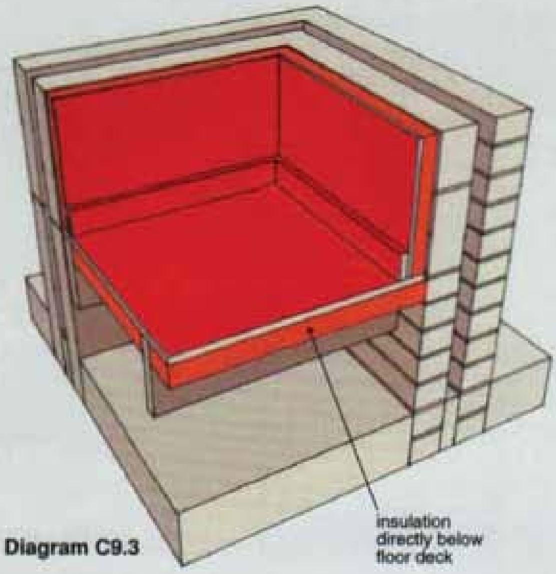


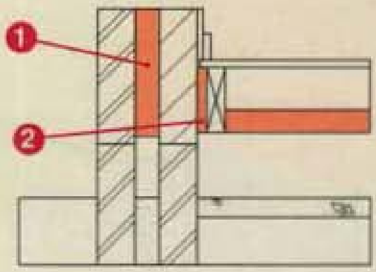
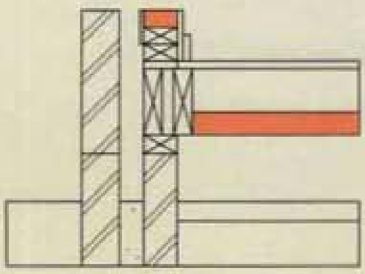
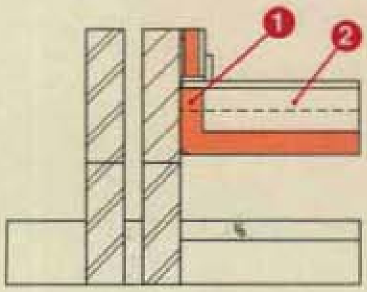
Diagram C9.3

BEST PRACTICE

An alternative way of avoiding a thermal bridge is to place the insulation directly below the floor deck, as in Diagram **C9.3**. This produces slightly higher surface temperatures than the solution shown in Diagram **C9.2**.

Note. Where pipework is located in the floor void, it would be less susceptible to freezing if it was routed above the floor insulation.

SUMMARY OF RECOMMENDATIONS

Wall construction	Junction with floor construction
Cavity insulated wall	**A**  **Best Practice** **1** Take cavity insulation down to same level as the floor insulation, AND **2** Insulate between the last joist and wall.
Timber framed wall	**B**  **Best Practice** The insulation is supported between the timber floor joists.
Internally insulated wall **Note:** Internal insulation should include a vapour check on the warm side of the insulation	**C**  **Best Practice** Insulate between the last joist and wall, and either **1** Turn insulation up against the wall, or **2** Position the insulation directly under the floor deck.

CHAPTER

10

Perimeter floor insulation

Introduction

An uninsulated ground floor slab is coldest at its perimeter, where the heat loss path to the outside air is at its shortest.

Perimeter floor insulation can be used to combat this perimeter heat loss and is an alternative to insulating the whole ground floor.

The illustrations in this chapter show the use of:

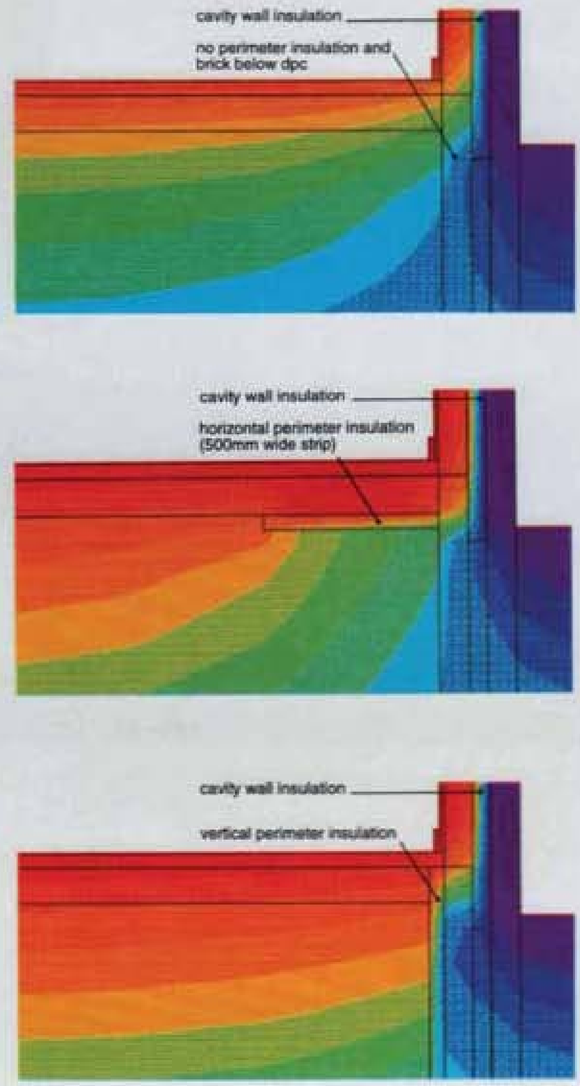
- horizontal perimeter insulation below the slab
- vertical perimeter insulation (in three alternative positions - on the internal face of the wall, in the cavity and externally)
- insulating blockwork foundations.

For simplicity, most of the illustrations show perimeter insulation in combination with cavity wall insulation. However, the summary table at the end of this chapter notes any additional precautions needed if the wall insulation is not placed in the cavity.

The three diagrams on the right show the different heat loss patterns for an uninsulated floor, horizontal perimeter insulation and vertical perimeter insulation.

All the details shown in this chapter reduce the thermal bridge at the floor perimeter sufficiently to avoid the risk of mould growth. However, the surface temperatures of the floor are lower than comparable details with a continuous layer of floor insulation.

Sections through wall/floor junctions showing the effect of perimeter floor insulation



A HORIZONTAL PERIMETER INSULATION

MINOR THERMAL BRIDGE

In Diagram **A10.1**, a 500 mm wide strip of 50 mm thick extruded polystyrene avoids thermal bridging at the floor perimeter. Insulating blockwork is used for the inner leaf. The floor surface temperature directly above the insulation is lower than in Diagram **A10.2**.

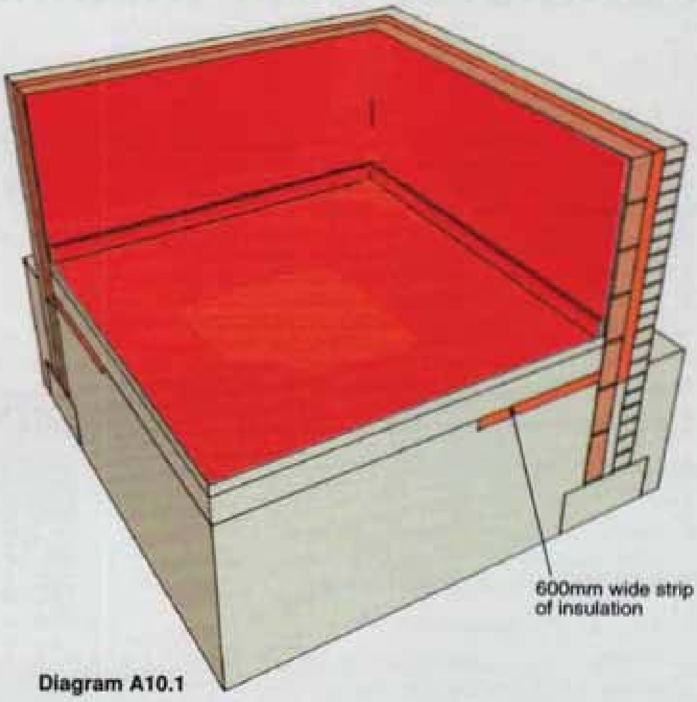


Diagram A10.1

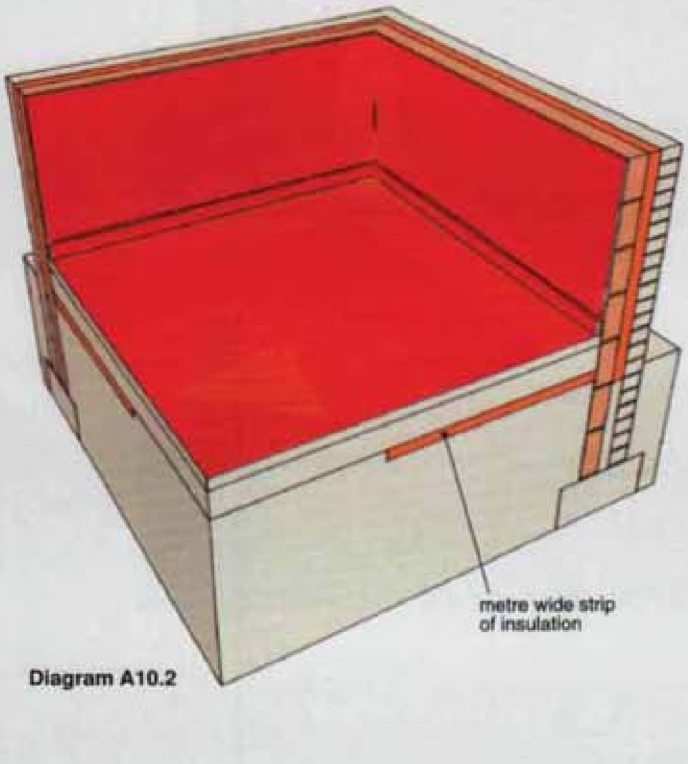


Diagram A10.2

BEST PRACTICE

In Diagram **A10.2**, the highest floor temperatures occur immediately above the perimeter insulation. The 'interior' of the slab is between 1°C and 2°C colder than if the floor insulation had been continuous, but is warm enough for there to be little risk of mould growth.

Calculation of perimeter floor insulation U-values

For comparison, the U-value for the ground floor of a semi-detached house would be improved from 0.67 W/m²K to about 0.57 W/m²K if a 500 mm wide strip of horizontal perimeter insulation were used, and to 0.5 W/m²K if a 1 m wide strip were used. If the whole floor were insulated with 50 mm thick extruded polystyrene, the U-value would be about 0.33 W/m²K. These U-values have been calculated using the formulae in BRE Information Paper 7/93.

B VERTICAL PERIMETER INSULATION – INSULATING BLOCKWORK FOUNDATIONS

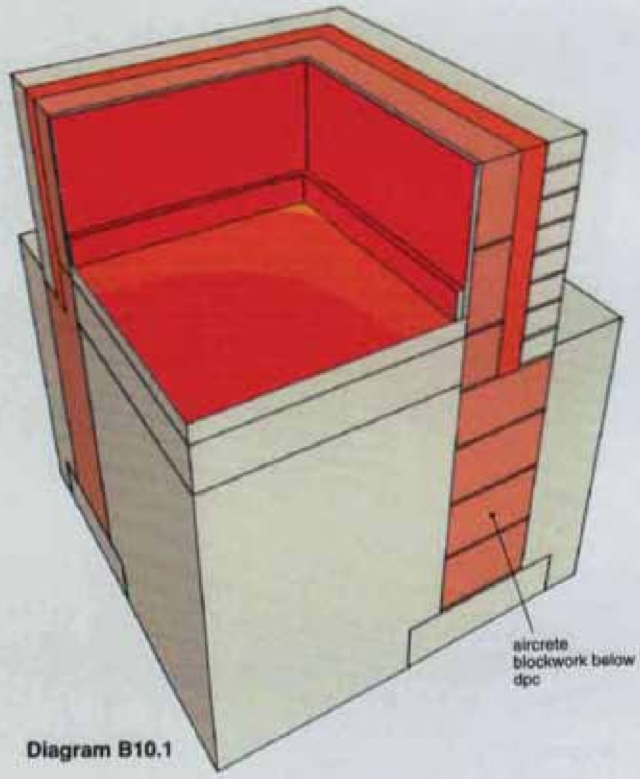


Diagram B10.1

THERMAL BRIDGE

The use of insulating blockwork in the foundations is sufficient to raise the surface temperature at the corner of the floor slab above the level at which there is a risk of mould growth. However, the area of orange in Diagram **B10.1** indicates that a thermal bridge still exists. Some additional floor or perimeter insulation is therefore recommended.

C VERTICAL INTERNAL PERIMETER INSULATION

MINOR THERMAL BRIDGE

In the thermal analysis, placing the vertical perimeter insulation against the inner leaf, as in Diagram **C10.1**, gave the best results of all the positions for vertical perimeter insulation. However, even with this construction the temperature falls below 15.5°C in the corner.

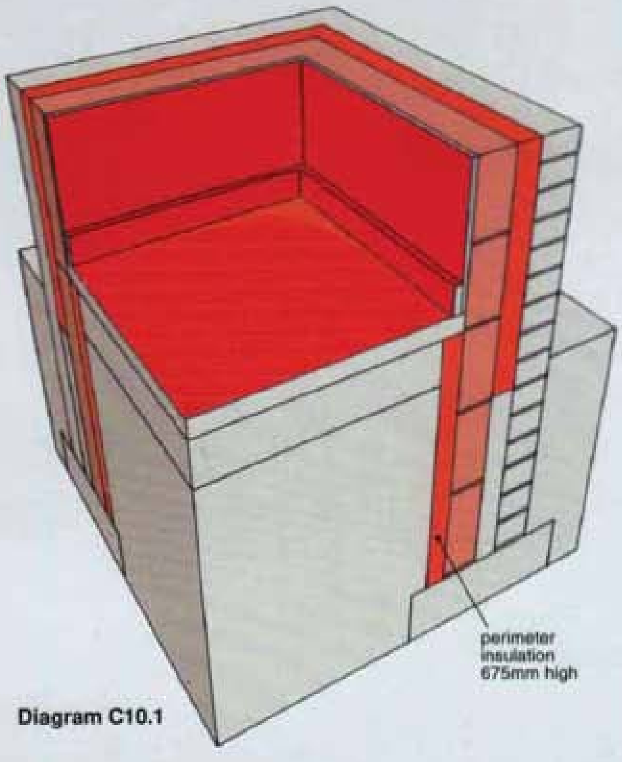


Diagram C10.1

D VERTICAL CAVITY PERIMETER INSULATION

THERMAL BRIDGE

When the vertical perimeter insulation was placed in the cavity, as in Diagram **D10.1**, the thermal analysis gave very similar results to using insulating blockwork foundations. The yellow area indicates that a thermal bridge exists at the external corner.

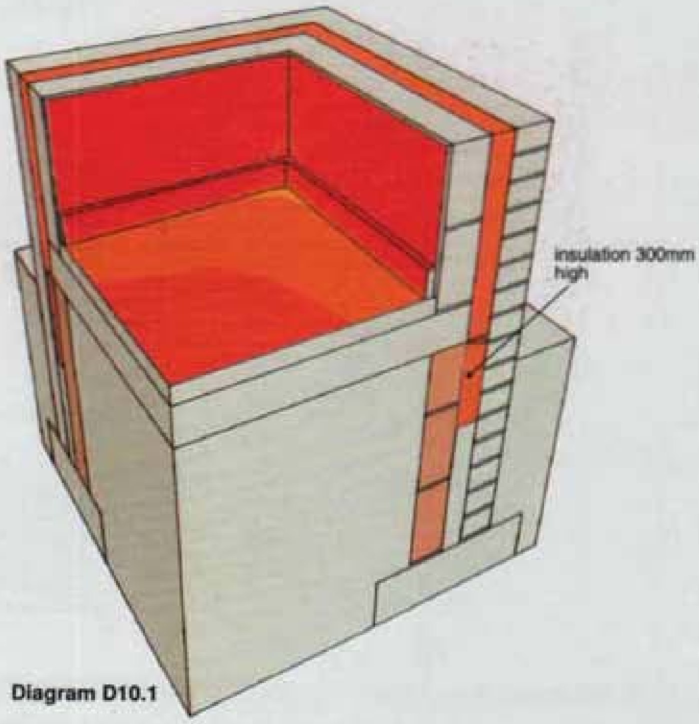


Diagram D10.1

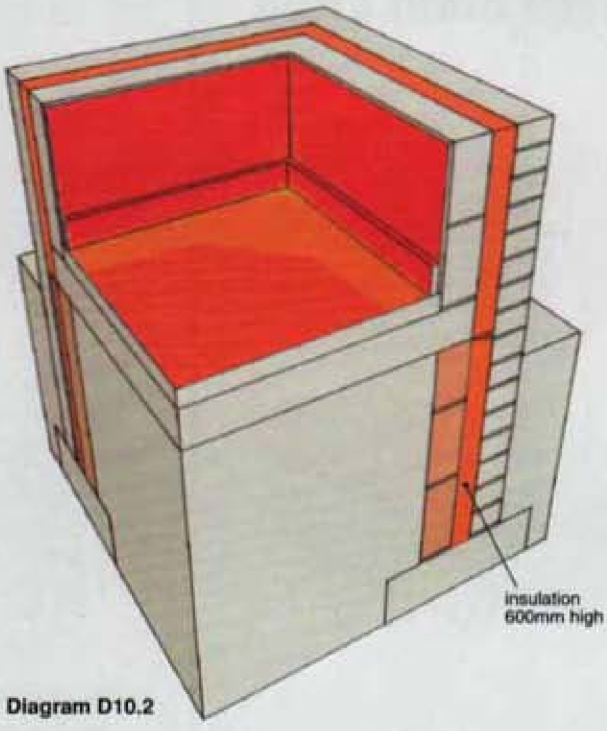


Diagram D10.2

THERMAL BRIDGE

Increasing the depth of the insulation below ground level, as in Diagram **D10.2**, reduces the area of the thermal bridge.

E VERTICAL EXTERNAL PERIMETER INSULATION

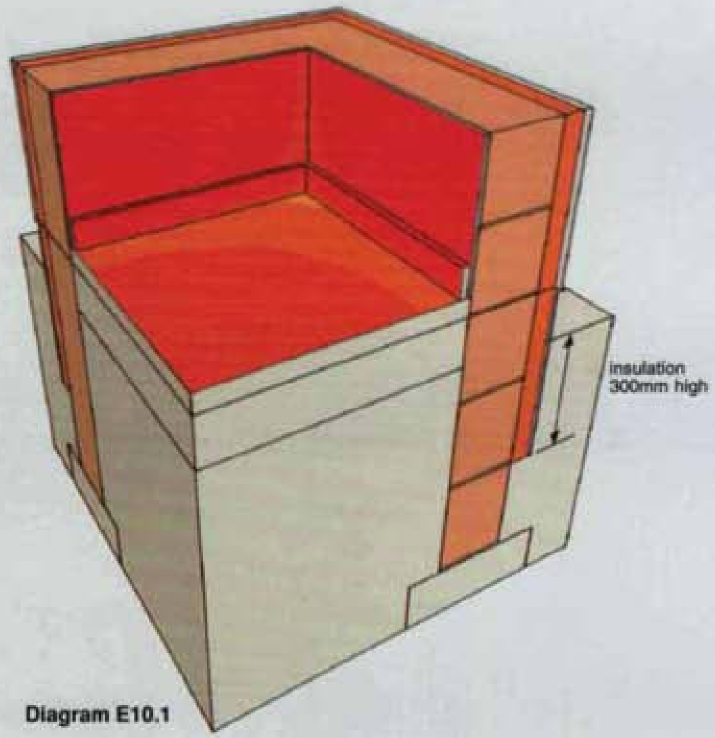


Diagram E10.1

THERMAL BRIDGE

In Diagram **E10.1** external perimeter insulation is used in combination with external wall insulation. The solid wall is constructed of insulating blockwork with a thermal conductivity of 0.3 W/m•K. The results are similar to the other constructions with vertical perimeter insulation.

THERMAL BRIDGE

Increasing the depth of the insulation below ground level, as in Diagram **E10.2**, marginally reduces the size of the thermal bridge.

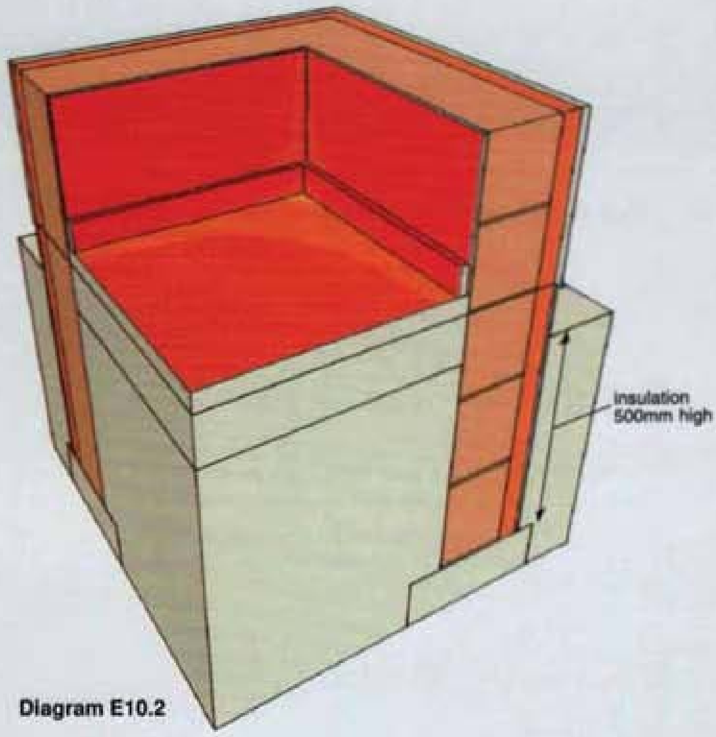
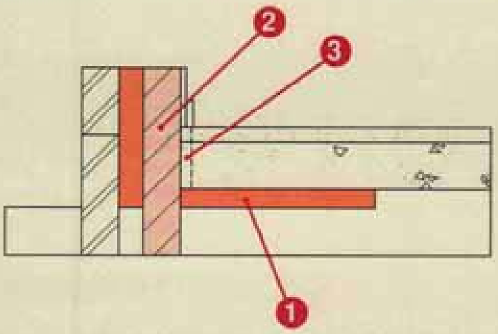


Diagram E10.2

SUMMARY OF RECOMMENDATIONS

Horizontal perimeter insulation

A



Best Practice

1. Use a perimeter strip of insulation at least 500 mm wide
2. For cavity insulation, use insulating blockwork for the inner leaf
3. For other forms of wall insulation, add edge insulation to the slab and screed.

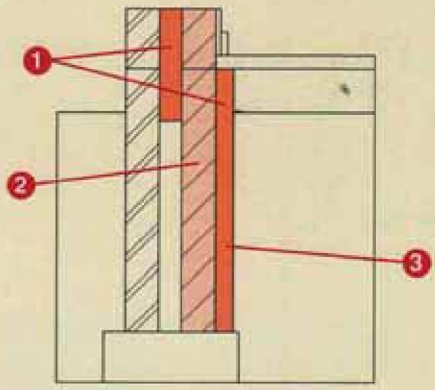
Vertical perimeter insulation

B Insulating blockwork foundations

Diagram B10.1 on page 65 does not avoid a thermal bridge.

Additional floor or perimeter insulation is recommended.

C Vertical internal perimeter insulation



Minimum recommendations

1. Overlap cavity and internal perimeter insulation
2. Use insulating blockwork below dpc
3. Take perimeter insulation down at 600 mm below dpc.

D Vertical cavity perimeter insulation

Diagrams D10.1 and D10.2 on page 66 do not avoid problems of thermal bridging.

Additional floor or perimeter insulation is recommended.

E Vertical external perimeter insulation

Diagrams E10.1 and E10.2 on page 67 do not avoid problems of thermal bridging.

Additional floor or perimeter insulation is recommended.

Note: i) Complete floor insulation is a better option than perimeter insulation (see Chapters 6 to 9).
ii) Minimum recommendations provide advice on reducing the risk of mould growth occuring.

Door thresholds

Introduction

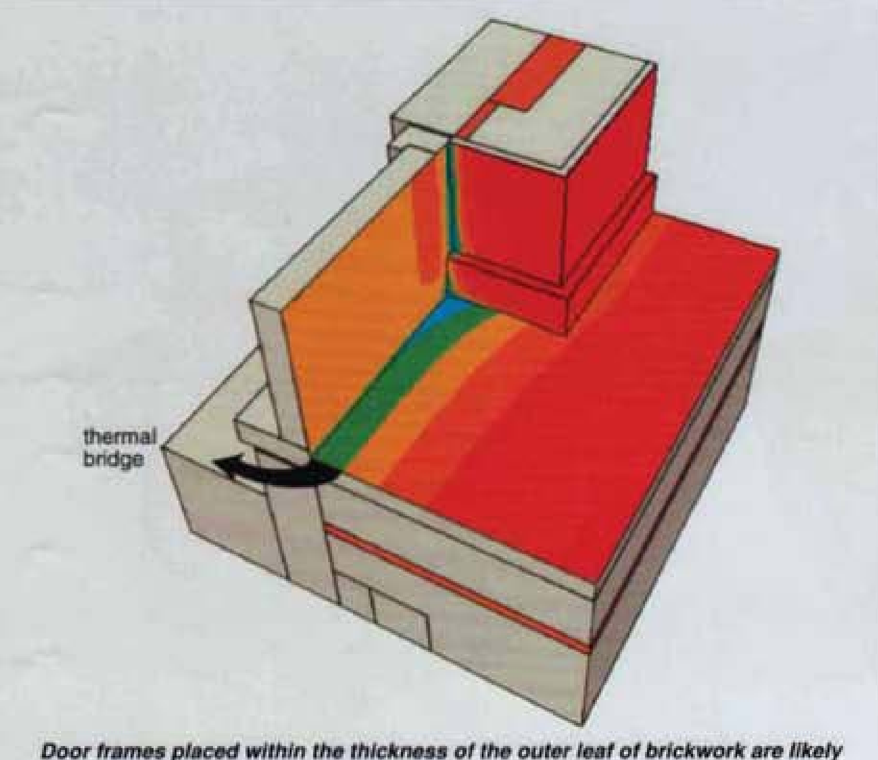
Door thresholds are an often neglected area of detailing, but they can be the subject of severe thermal bridging, as demonstrated in the illustration below.

This chapter examines thermal bridging at the junction of door thresholds with three different floor constructions:

- concrete ground slabs with insulation above
- concrete ground slabs with insulation below
- suspended timber ground floors with insulation between the joists.

Door thresholds are particularly vulnerable to thermal bridging for two main reasons. Firstly, surface temperatures are always lower at internal corners; this is because of the tendency, noted in other chapters, for the thermal contours to 'cut across' internal corners, in this case the angle between the door and the floor slab. Secondly, doors and their frames tend to be relatively thin and poorly insulated compared with other elements of construction - the internal surface of the solid timber door in the illustration below is about 3°C colder than that of the external wall and ground floor.

The examples in this chapter show not only how door thresholds can be detailed to minimise thermal bridging, but also that the use of insulated doors raises their surface temperatures to the same level as the external wall.



Door frames placed within the thickness of the outer leaf of brickwork are likely to pose a risk of mould growth at their junction with the floor and at reveals

A INSULATION ABOVE FLOOR

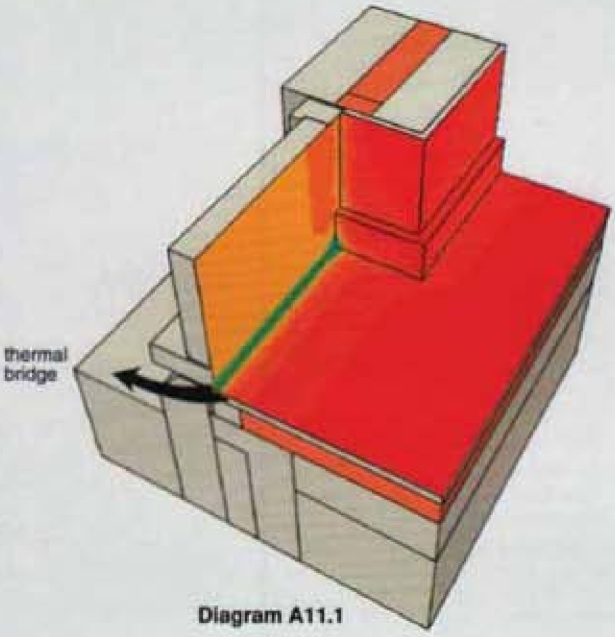


Diagram A11.1

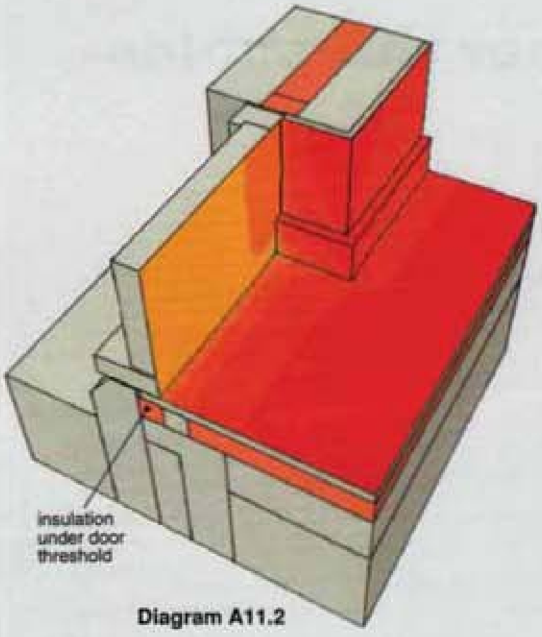


Diagram A11.2

RISK OF MOULD

With the door frame positioned as in Diagram **A11.1**, there is a thermal bridge at the door threshold. The door frame laps the insulated cavity closer by 20 mm, giving surface temperatures in the door frame/jamb junction as high as the solid 44 mm timber door.

SLIGHT RISK OF MOULD

Moving the door frame back so that insulation can be placed directly below the door threshold, as in Diagram **A11.2**, minimises the risk of mould growth in all but a small area in the corner.

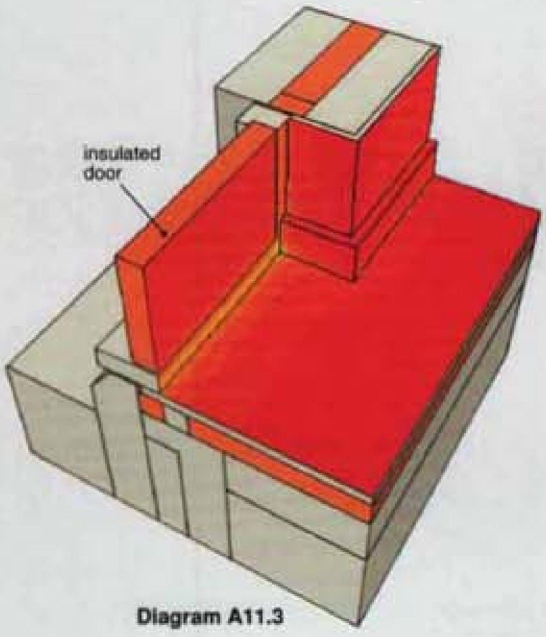


Diagram A11.3

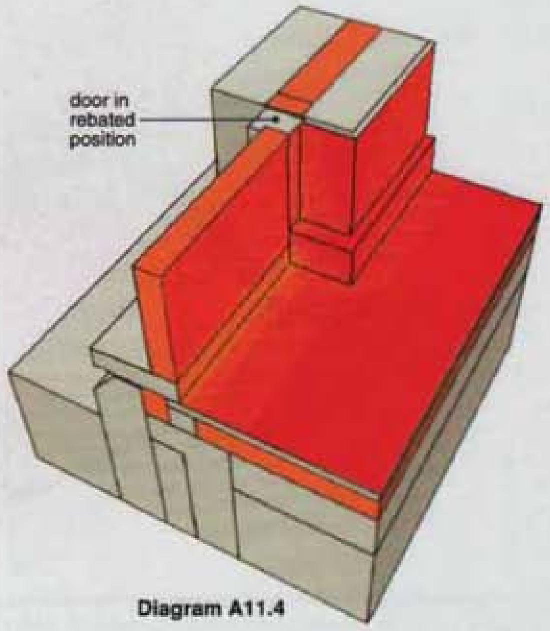


Diagram A11.4

MAJOR THERMAL BRIDGE

Replacing the solid timber door with an insulated door, as in Diagram **A11.3**, raises temperatures significantly, but a thermal bridge still exists.

BEST PRACTICE

The best results are obtained when the door frame is in the rebated position and the floor insulation is placed directly below the door threshold, as in Diagram **A11.4**.

B INSULATION BELOW SLAB

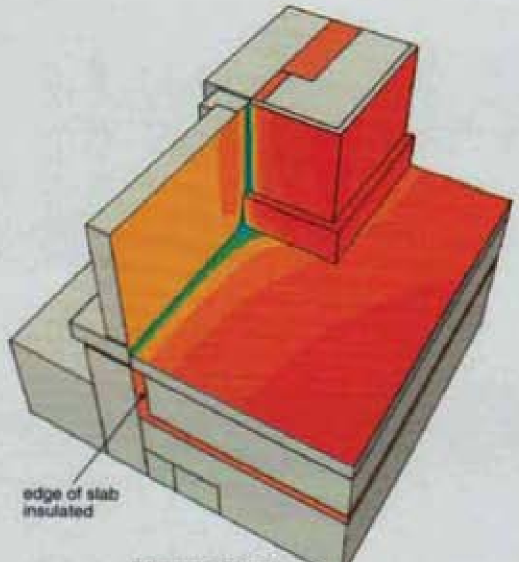


Diagram B11.1

RISK OF MOULD

Insulating the edge of the slab is not sufficient to avoid a thermal bridge if the door frame is set forward, as in Diagram **B11.1**.

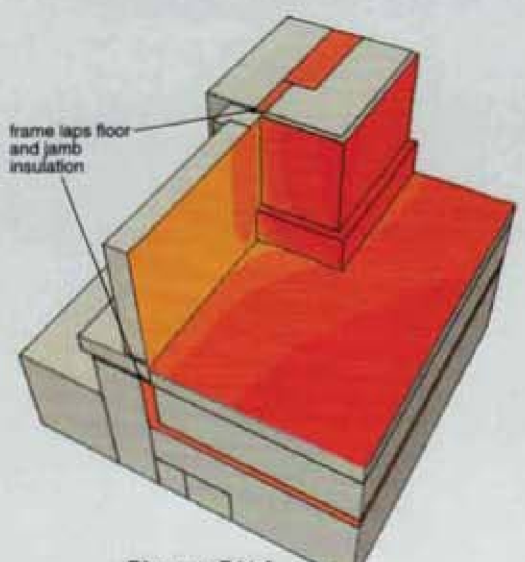


Diagram B11.2

THERMAL BRIDGE

Setting the door frame back 20 mm to lap the insulation at the slab edge and the jamb, as in Diagram **B11.2**, raises the minimum surface temperatures significantly. Setting the door frame back further and using an insulated door gives the best results.

C SUSPENDED TIMBER GROUND FLOOR

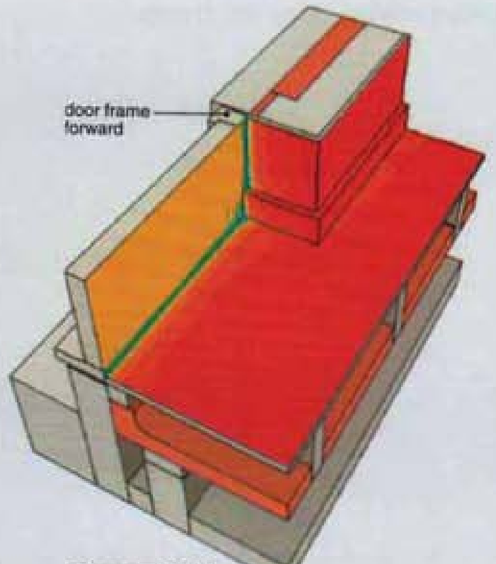


Diagram C11.1

RISK OF MOULD

With the door frame set forward, as in Diagram **C11.1**, there is a serious thermal bridge around the perimeter of the frame.

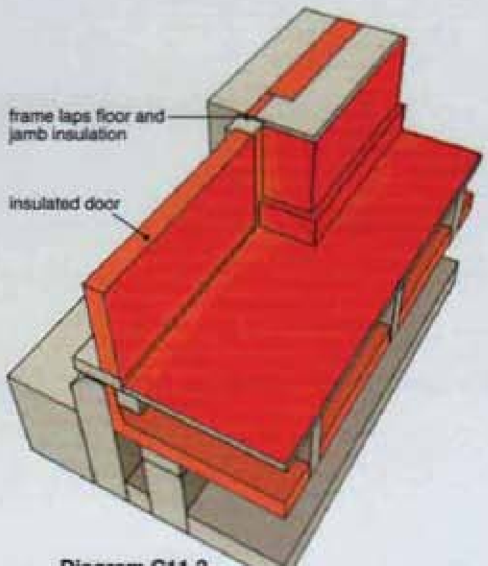


Diagram C11.2

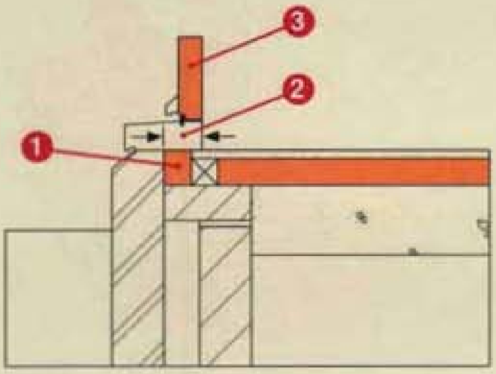
BEST PRACTICE

In Diagram **C11.2**, the door frame is set back 45 mm to lap both the jamb insulation and the upstand floor insulation. The solid timber door in Diagram **C11.1** is replaced with an insulated door.

The netting used to support the insulation over the main floor area should be extended to support the insulation at the threshold.

SUMMARY OF RECOMMENDATIONS

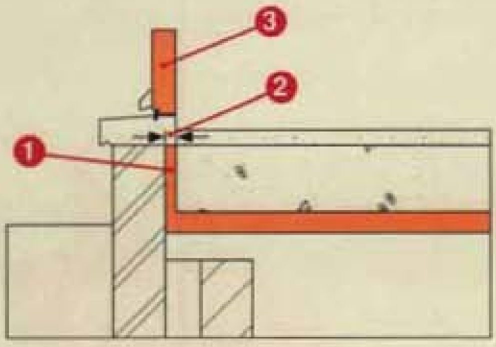
A Insulation above floor



Best Practice

1. Extend floor insulation under the door threshold
2. Set the door frame back to lap the edge of the insulation by 40 mm, AND
3. Use an insulated door.

B Insulation below slab



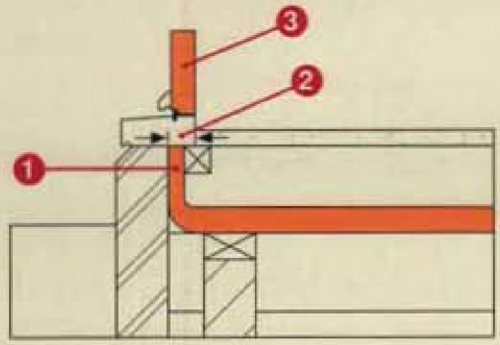
Best Practice

1. Insulate the edge of the floor slab
2. Set the door frame back to lap the edge insulation by 40 mm (minimum 20 mm shown), AND
3. Use an insulated door.

Set the door threshold further back to give a larger overlap with the insulation.

Note: Diagram B11.2 on page 71 does not show an insulated door which is recommended in the Best Practice solution.

C Suspended timber ground floor



Best Practice

1. Turn floor insulation up to meet underside of door threshold
2. Set door frame back to lap the upturned floor insulation by 40 mm (shown), AND
3. Use an insulated door.

Note: The minimum lap between the door frame and upturned floor insulation is 20 mm. A lap of 40 mm is the preferred solution.

CHAPTER 12

Separating walls

Introduction

This chapter looks at the potential thermal bridging problems of three types of separating walls:

- solid masonry (the examples use 200 mm thick blockwork which has a density of 2000 kg/m^3)
- masonry wall with a 75 mm cavity (the examples use blockwork which has a density of 1400 kg/m^3)
- timber framed separating wall.

The results of the thermal analysis show that the risk of mould growth at separating walls is relatively slight compared with other elements of construction. However, the way the floor insulation is detailed at the junction with the separating wall, and the density of blockwork below dpc level have a strong influence on the severity of the thermal bridge. The four examples below highlight the differences in performance.

Where insulation is placed above the slab and dense blockwork is used below the dpc, as in the first example, the separating wall forms a thermal bridge. The relatively cold mass of blockwork above dpc level will fairly quickly cause chilling of the separating wall once the heating has been turned off.

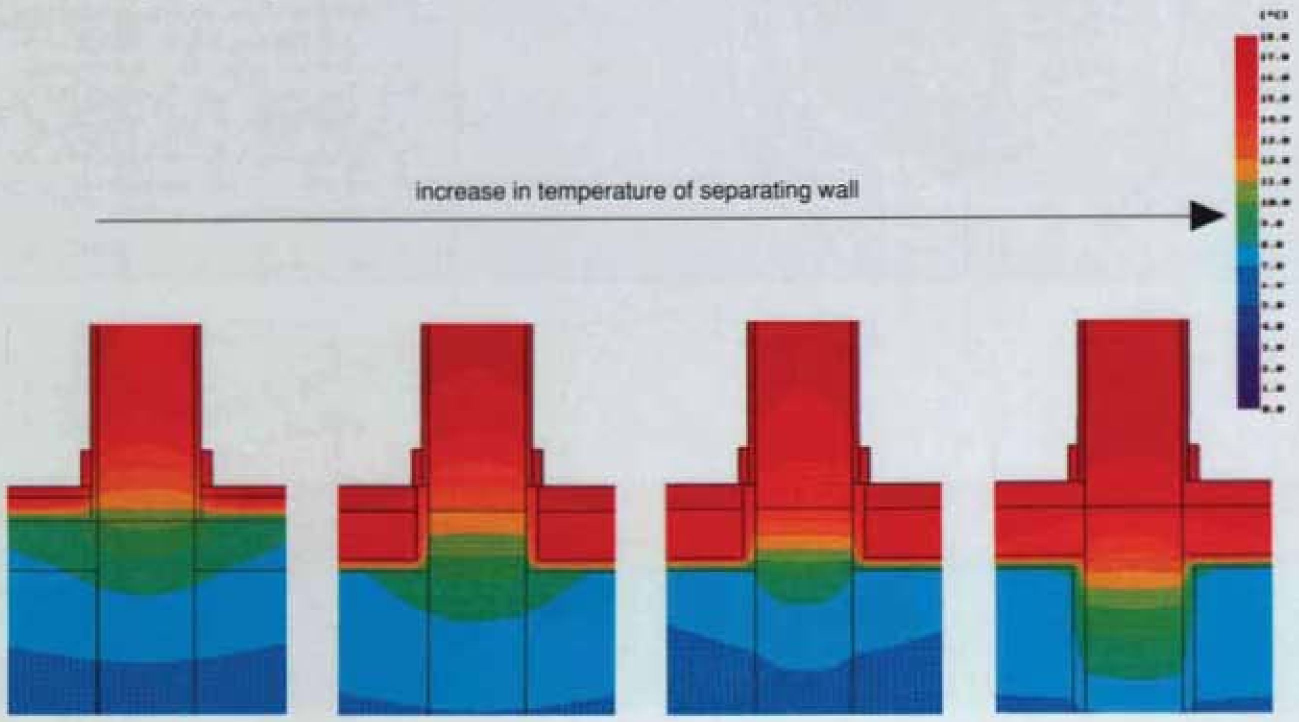
In the second example, the vertical insulation at the edge of the slab raises the temperature of the blockwork at dpc level by almost 2°C compared with the first example. The temperature is raised a further 2°C if insulating blockwork is used below dpc level, as in the third example.

The last example, in which 300 mm high strips of vertical insulation are placed each side of the insulating blockwork separating wall, achieves the best results.

These four examples clearly show the advantages of:

- extending the length of the thermal bridge path between the warm interior and the cold exterior or ground
- using materials with a low thermal conductivity in the thermal bridge path.

Sections through separating walls showing the effect of different floor insulation details



- insulation above slab
- dense blockwork below dpc

- insulation below slab
- edge insulation to slab
- dense blockwork below dpc

- insulation below slab
- edge insulation to slab
- insulating blockwork below dpc (conductivity 0.32 W/m•K)

- insulation below slab
- vertical insulation below slab
- insulating blockwork below dpc (conductivity 0.32 W/m•K)

A SOLID SEPARATING WALL – FLOOR INSULATION ABOVE SLAB

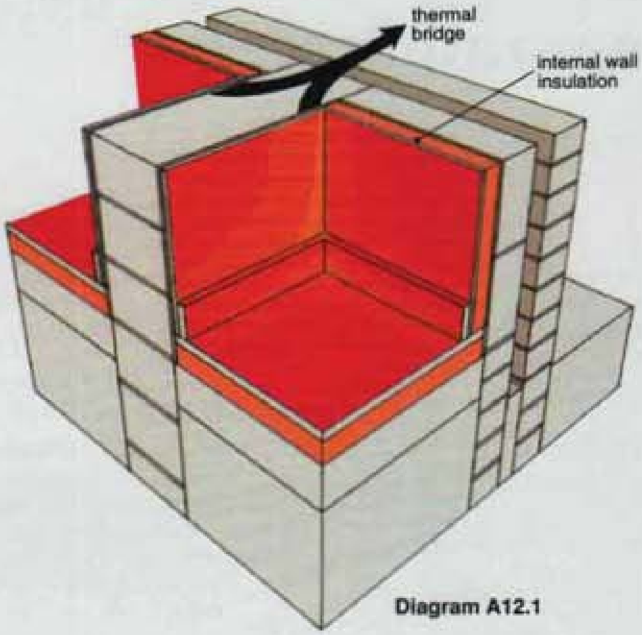


Diagram A12.1

THERMAL BRIDGE

Where the external walls are of timber framed construction or have internal wall insulation, as in Diagram **A12.1**, a thermal bridge exists.

Under steady state conditions, the high insulation level of the external wall helps to maintain sufficiently high temperatures to avoid mould growth. However, as room temperatures fall at the end of the heating period, the separating wall will cool more quickly than the surrounding insulated surfaces.

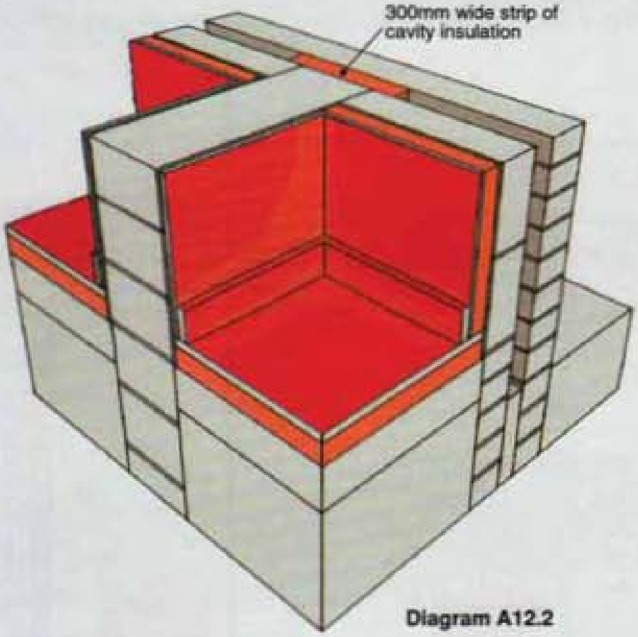


Diagram A12.2

MINOR THERMAL BRIDGE

In Diagram **A12.2**, 300 mm wide strips of mineral wool cavity batts have been placed in the cavity. They not only limit heat loss through the separating wall, but also restrict flanking sound transmission as required by Approved Document E of the 1991 Building Regulations for England and Wales.

Increasing the width of the mineral wool batts to say 450 mm, would marginally raise the surface temperatures.

BEST PRACTICE

With cavity insulation, as in Diagram **A12.3**, the potential thermal bridge through the dense masonry of the separating wall to the outside is avoided.

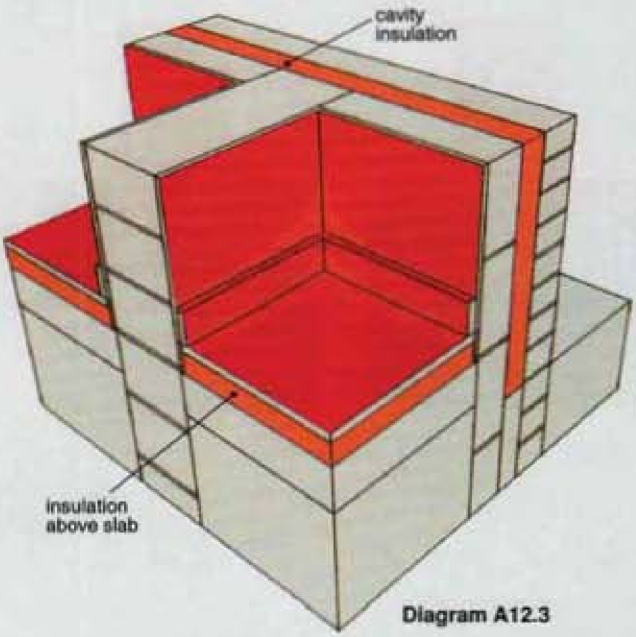


Diagram A12.3

B SOLID SEPARATING WALL – CAVITY INSULATED EXTERNAL WALL – FLOOR INSULATION BELOW SLAB

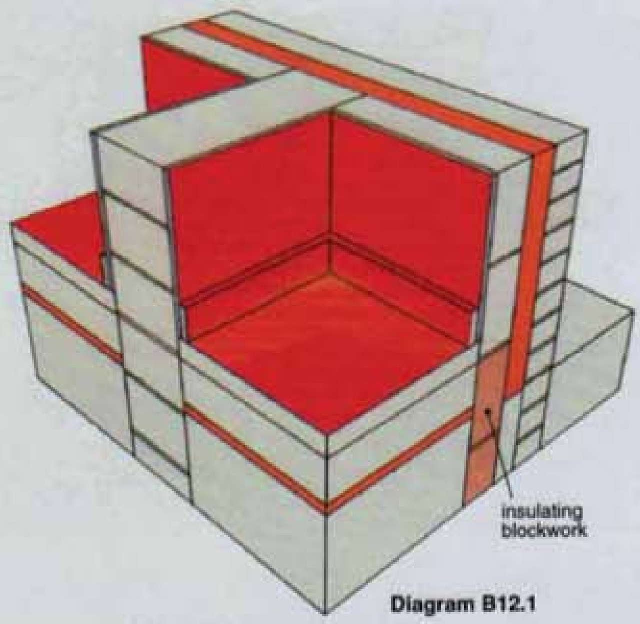


Diagram B12.1

MINOR THERMAL BRIDGE

With cavity insulation and insulating blockwork for the inner leaf below the dpc, as in Diagram **B12.1**, wall surfaces are warm enough to avoid mould growth, but the orange area in the corner indicates that there is a minor thermal bridge.

NO THERMAL BRIDGE

The thermal bridge is avoided by adding edge insulation to the slab and screed, as in Diagram **B12.2**. Adding insulation to the edge of the slab and not the screed would still leave a minor thermal bridge.

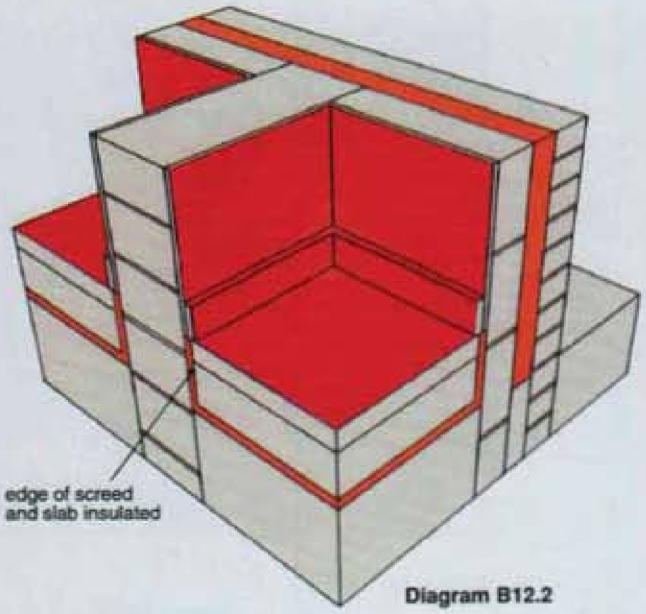


Diagram B12.2

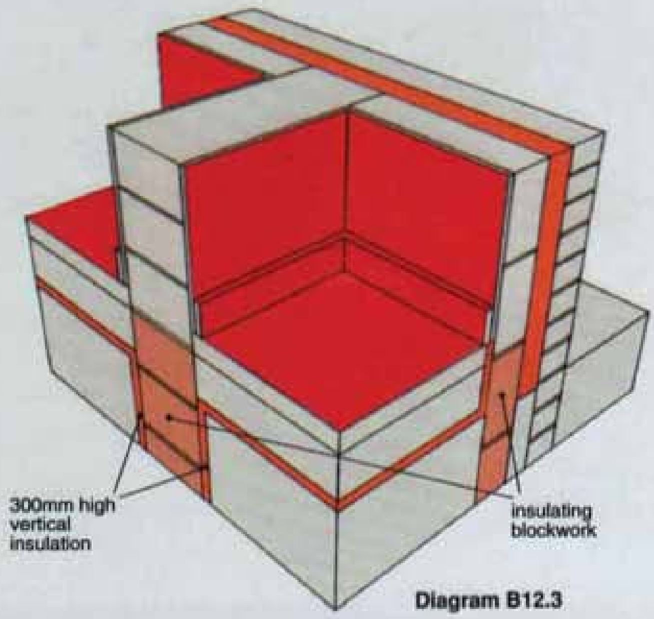


Diagram B12.3

BEST PRACTICE

The best results were obtained with the detail in **B12.3** which has insulation at the edge of the slab and screed and insulating blockwork below dpc level for the inner leaf and solid separating wall.

B SOLID SEPARATING WALL – TIMBER FRAME EXTERNAL WALL – FLOOR INSULATION BELOW SLAB

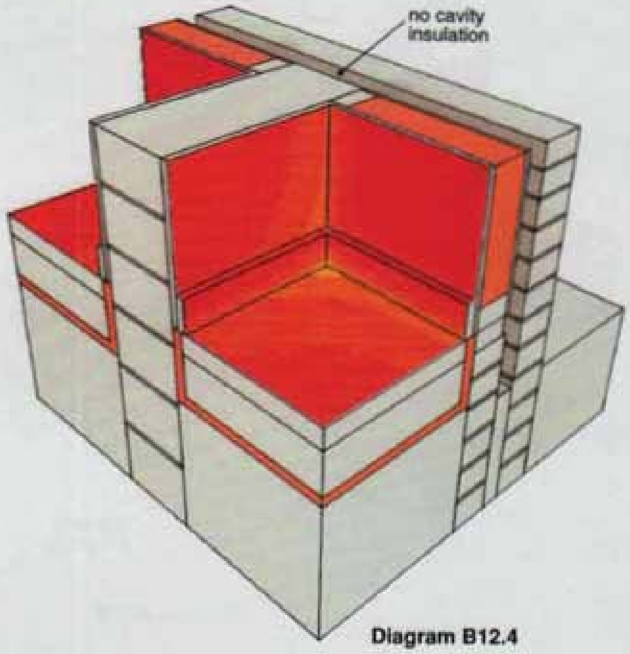


Diagram B12.4

THERMAL BRIDGE

Where the end of the separating wall is uninsulated, as in Diagram **B12.4**, a thermal bridge exists at the separating wall even where the floor insulation is turned up to insulate the edge of the floor slab.

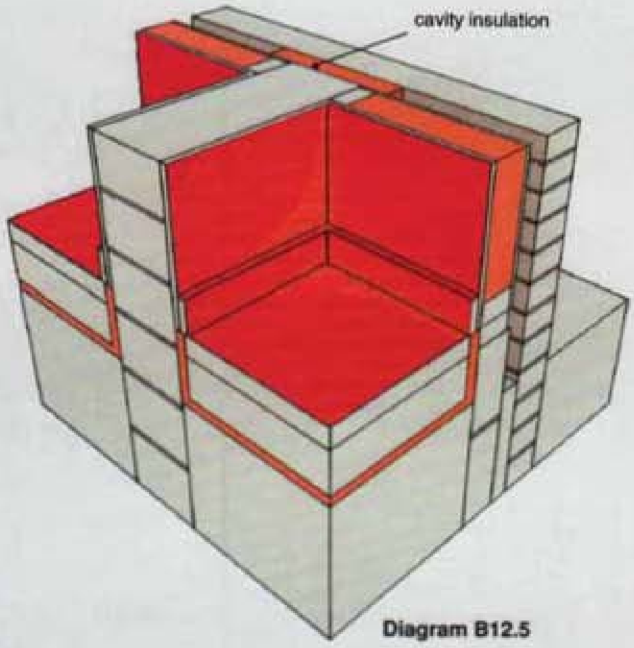


Diagram B12.5

MINOR THERMAL BRIDGE

By insulating the end of the separating wall in the cavity of the external wall, as in Diagram **B12.5**, the effect of the thermal bridge is minimised.

BEST PRACTICE

The best results were obtained by insulating the end of the separating wall in the cavity of the external wall and using insulating blockwork below the dpc, as in Diagram **B12.6**.

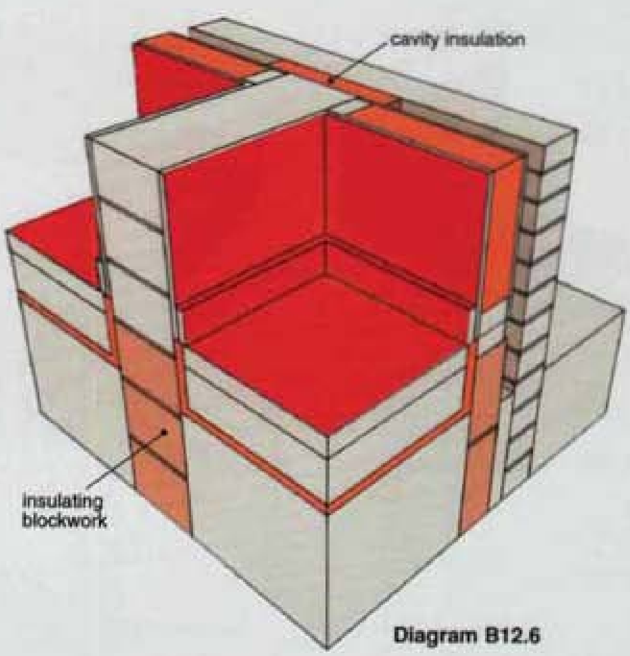


Diagram B12.6

C CAVITY SEPARATING WALL – FLOOR INSULATION ABOVE SLAB

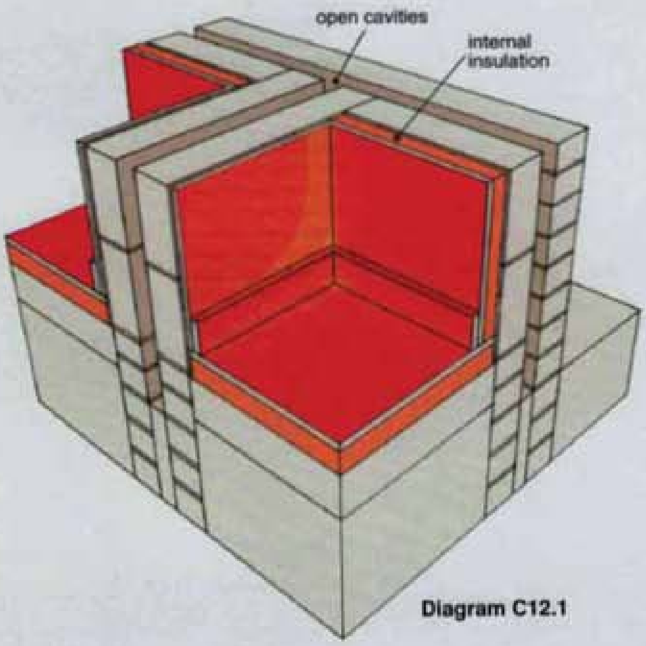


Diagram C12.1

MAJOR THERMAL BRIDGE

Where the external wall is insulated internally, as in Diagram **C12.1**, the cold air in the external wall cavity is free to mix with the air in the separating wall cavity, resulting in lower surface temperatures for a cavity separating wall than for a solid separating wall.

BEST PRACTICE

Placing a 450 mm wide strip of mineral wool insulation in the cavity, as in Diagram **C12.2**, prevents the warm air in the separating wall cavity from mixing with the cold air in the external wall cavity.

This results in the surface temperatures of the cavity separating wall being warmer than those of the solid separating wall. The increased temperature is also due to the use of a medium density block in the cavity separating wall and a dense block in the solid separating wall.

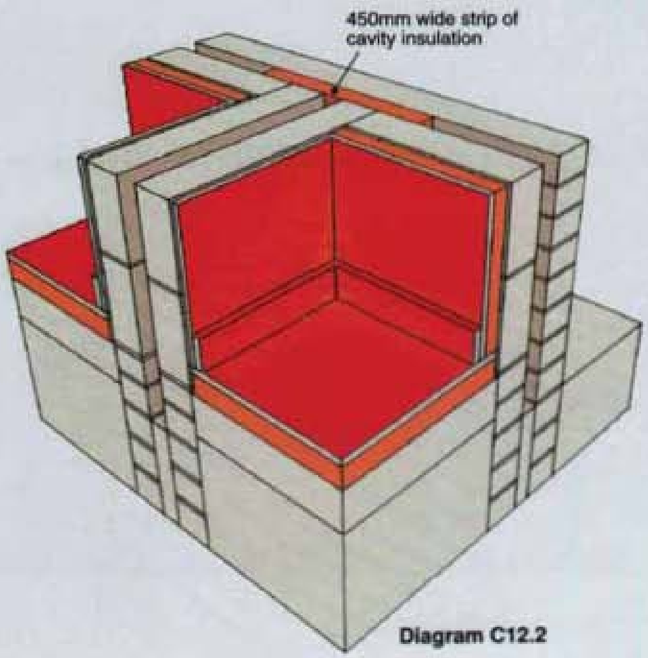


Diagram C12.2

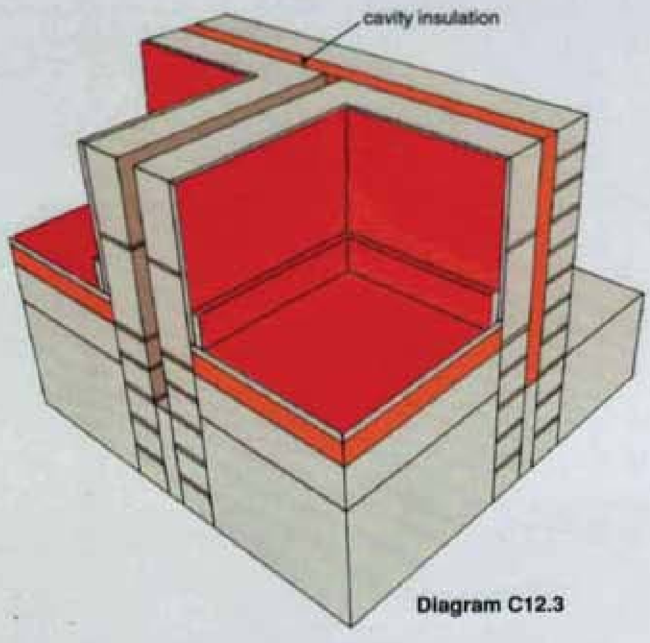


Diagram C12.3

BEST PRACTICE

With a cavity insulated external wall and insulation above the slab, as in Diagram **C12.3**, thermal bridging is avoided, even where brickwork is used below dpc level. Using an insulating block below dpc level would result in higher temperatures at skirting level (see Diagram **A6.2** in Chapter 6 for details).

C CAVITY SEPARATING WALL – FLOOR INSULATION ABOVE SLAB – (continued)

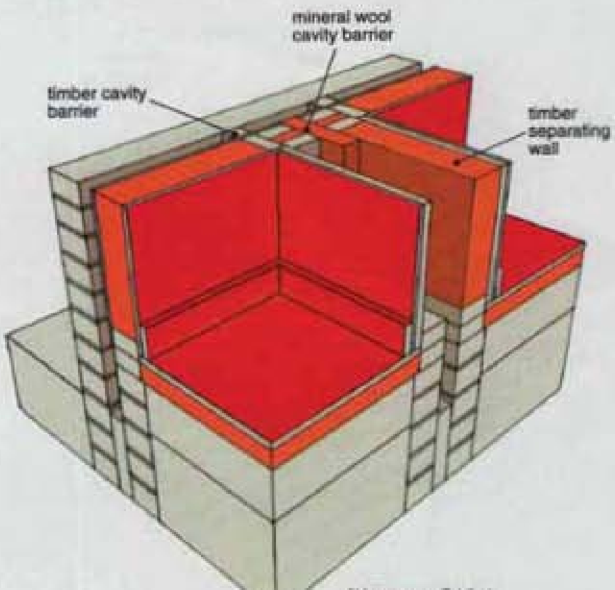


Diagram C12.4

BEST PRACTICE

Constructing both the external and separating walls in timber frame, as in Diagram **C12.4**, gives similar results to Diagram **C12.3**. With a timber framed separating wall, it is important that the cavity barriers noted in the diagram prevent cold air from the external wall cavity mixing with the warmer air in the cavity of the separating wall.

D CAVITY SEPARATING WALL – FLOOR INSULATION BELOW SLAB

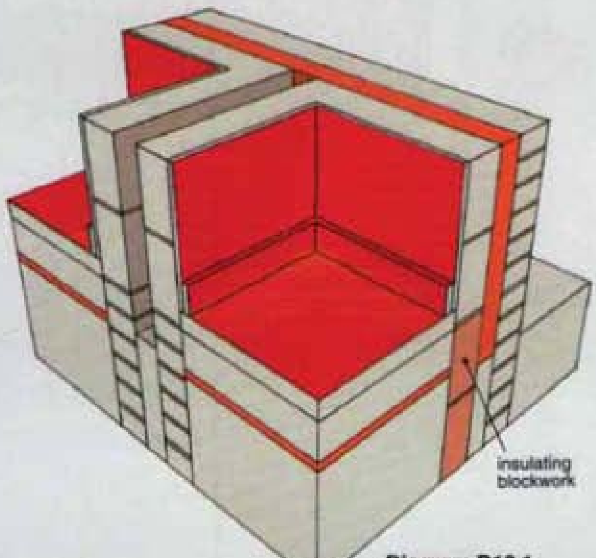


Diagram D12.1

MINOR THERMAL BRIDGE

Cavity separating walls give very similar surface temperatures to the equivalent solid separating walls shown in Section **B** of this chapter.

For example, the severity of the thermal bridge in Diagram **D12.1** is almost exactly the same as in Diagram **B12.1**. The marginally higher temperature of the cavity separating wall can be attributed to the use of a medium density block, compared with a dense block in the solid separating wall in Diagram **B12.1**.

BEST PRACTICE

The minor thermal bridge indicated by the orange area, in the corner of the floor in Diagram **D12.1**, is avoided if the floor insulation is turned up to insulate the edge of the slab and screed, as in Diagram **D12.2**.

The use of other external wall constructions in conjunction with insulation below the slab should give similar results to those in Section **B**. The advice given there should be followed.

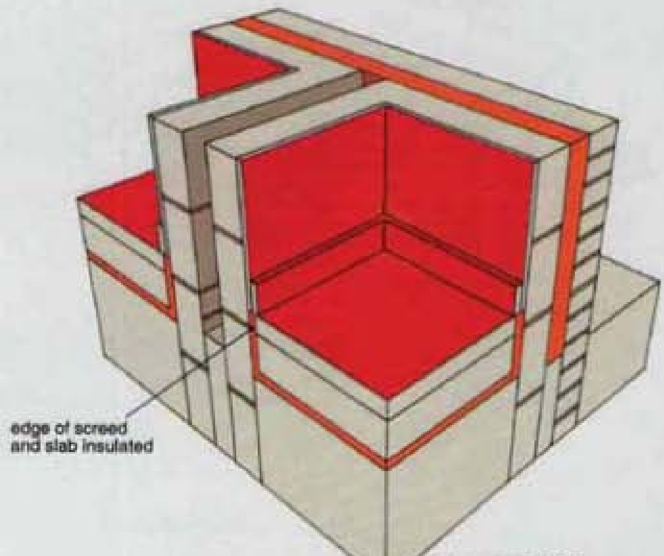


Diagram D12.2

E STEP IN CAVITY SEPARATING WALL – JUNCTION WITH GROUND FLOOR

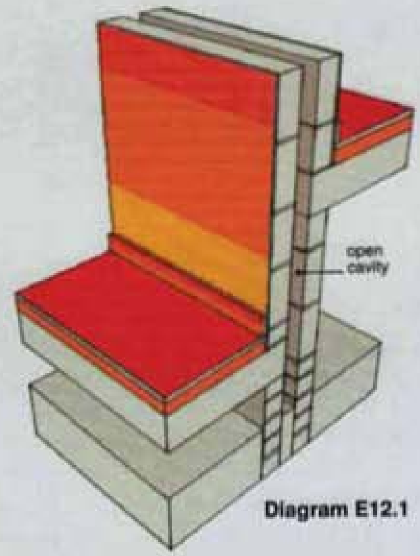


Diagram E12.1

MAJOR THERMAL BRIDGE

Diagram **E12.1** shows a typical detail of a stepped separating wall. Cavity separating walls are normally used at steps to make the weatherproof detailing easier at roof level. Suspended floors, in this case concrete, are often used at steps to avoid the need for extensive back filling.

Diagram **E12.1** shows that there is a significant thermal bridge through the separating wall to the sub-floor void of the higher dwelling.

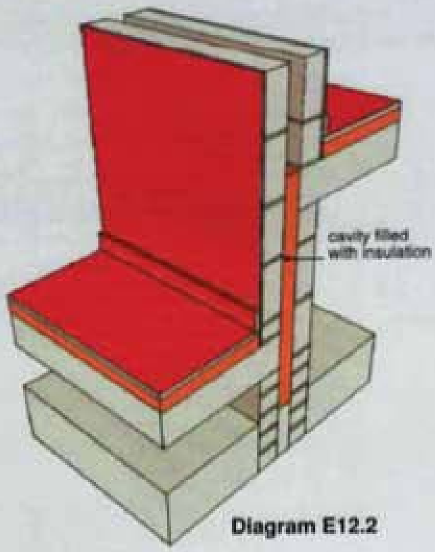


Diagram E12.2

BEST PRACTICE

Placing insulation in the cavity, as in Diagram **E12.2**, raises temperatures dramatically and eliminates the thermal bridge.

F STEP IN CAVITY SEPARATING WALL – JUNCTION WITH CEILING

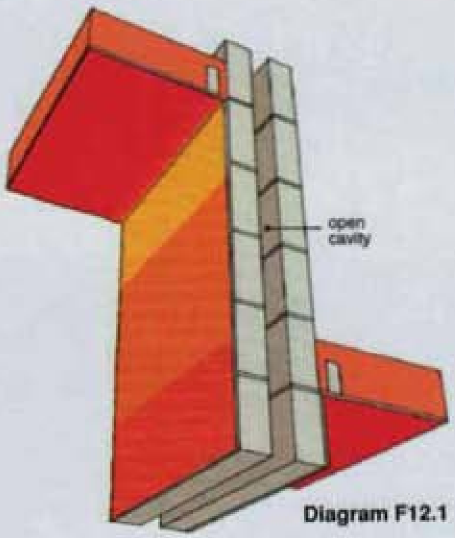


Diagram F12.1

MAJOR THERMAL BRIDGE

Diagram **F12.1** shows a typical detail of a stepped separating wall at ceiling level. The thermal bridge through the separating wall to the roof void of the lower dwelling is similar in magnitude to that in Diagram **E12.1**.

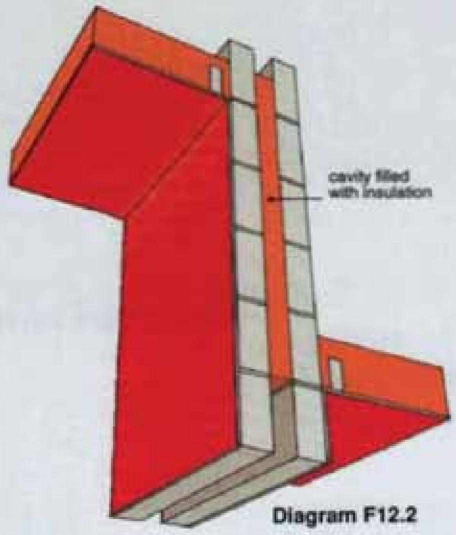


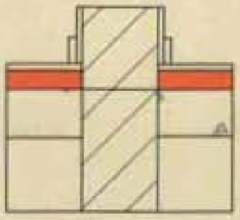
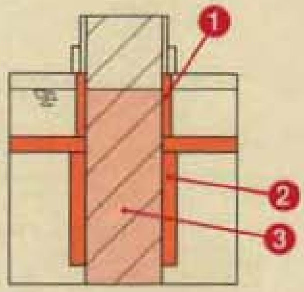
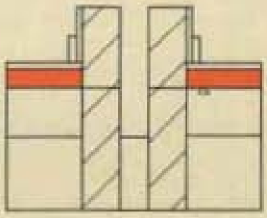
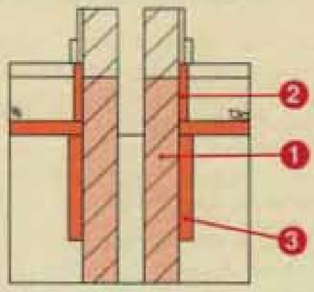
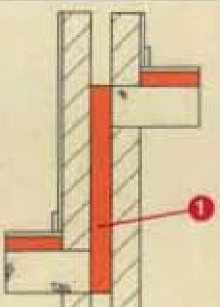
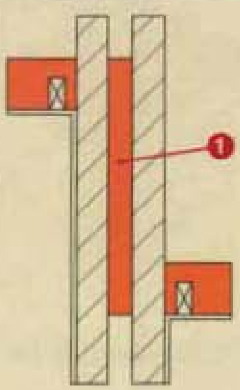
Diagram F12.2

BEST PRACTICE

Placing insulation in the cavity, as shown in Diagram **F12.2**, is just as effective as at ground floor level.

Mineral wool cavity batts are the most appropriate material for use in the wall cavities in Junctions E or F of this chapter. Their use is unlikely to impair the sound performance of the wall.

SUMMARY OF RECOMMENDATIONS

Wall construction	Floor insulation position: Above slab	Floor insulation position: Below slab
Solid separating wall Blockwork 200 mm thick, density 2000 kg/m³	**A**  **Best Practice** With cavity wall insulation this is a **good solution** for avoiding thermal bridge problems. For other external wall constructions, place a strip of insulation across the end of the separating wall.	**B**  **Best Practice** For all wall constructions, EITHER **1** Provide edge insulation to the slab and screed **2** Provide vertical insulation below slab level, OR **3** Use insulating blockwork below dpc level. In addition, where cavity insulation is not used, place a strip of insulation across the end of the separating wall.
Cavity separating wall Blockwork density 1400 kg/m³, cavity 75 mm wide	**C**  **Best Practice** For cavity wall insulation and timber framed construction this is a **good solution** for avoiding thermal bridge problems. For other external wall constructions, place a strip of insulation across the end of the separating wall.	**D**  **Best Practice** For cavity insulated walls, **1** Use insulating blockwork below dpc **2** Provide edge insulation to the slab and screed, or **3** Provide vertical insulation below slab level. For other external wall constructions, place a strip of insulation across the end of the separating wall.
Steps in cavity separating wall Blockwork density 1400 kg/m³, cavity 75 mm wide	**Junction with ground floor** **E**  **Best Practice** **1** Place insulation in the cavity between the two floor levels.	**Junction with ceiling** **F**  **Best Practice** **1** Place insulation in the cavity between the two ceiling levels.

Separating floors

Introduction

This chapter shows the potential thermal bridging problems associated with concrete separating floors. Three forms of construction are covered:

- a dense concrete slab with screed, combined with an external cavity wall with continuous cavity insulation
- a dense concrete slab with screed, combined with an external cavity wall and a steel angle bolted back to the floor slab to support the outer leaf
- a concrete floor slab with floating screed and battened out ceiling, combined with internal wall insulation.

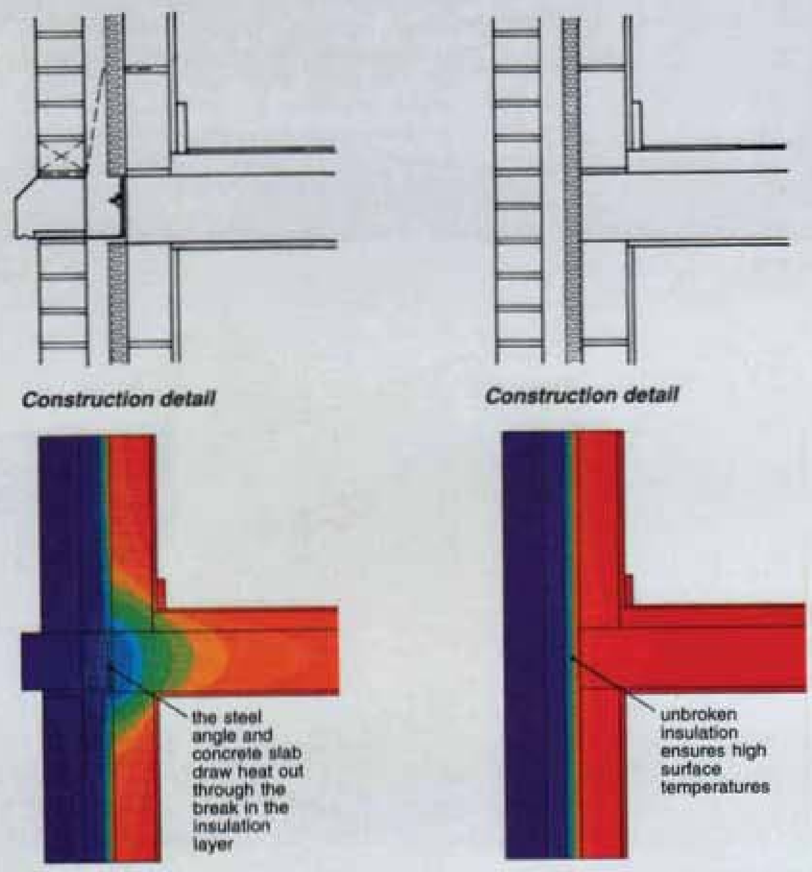
The results of the thermal analysis highlight the importance of maintaining the continuity of the insulation layer. The illustrations below show an extreme example of a thermal bridge caused by a break in the insulation layer.

In the illustration on the right, the partial cavity fill provides a continuous layer of insulation. This results in very little variation in temperature between the blockwork inner leaf and the concrete floor slab.

Where the insulation is interrupted, as in the illustration on the left, there is a serious thermal bridge. This is made worse by the presence of the steel angle which conducts heat rapidly from the edge of the floor slab to the outside.

The floor slab is about 8°C colder where the edge of the slab is not insulated. In contrast, the heat flowing through the steel warms up the outer leaf. The effect of the thermal bridge can be seen to extend well into the building. Floor and ceiling temperatures are about 2°C lower as a consequence of the thermal bridge.

Sections through separating walls showing the effect of different floor insulation details



Wall insulation interrupted by steel angle supporting outer leaf

Wall with continuous cavity insulation

A CAVITY INSULATED WALL – ANGLE SUPPORTING OUTER LEAF

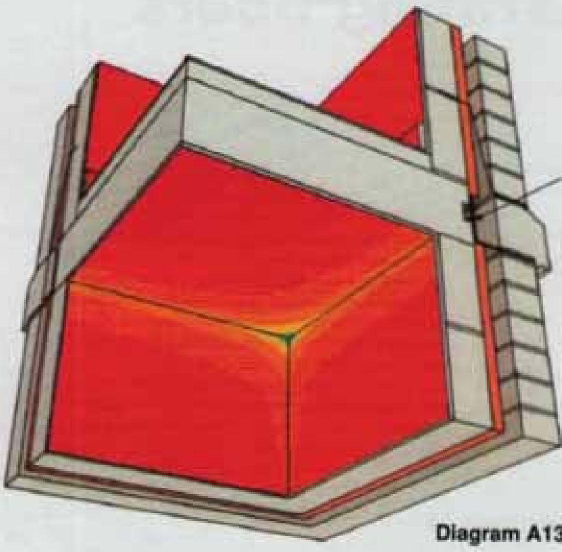


Diagram A13.1

SLIGHT RISK OF MOULD

In Diagram **A13.1**, the steel angle supporting the outer leaf is bolted directly to the edge of the concrete floor. The cavity insulation is stopped each side of the supporting angle. This break in the insulation results in a thermal bridge, with a risk of mould growth in the corner.

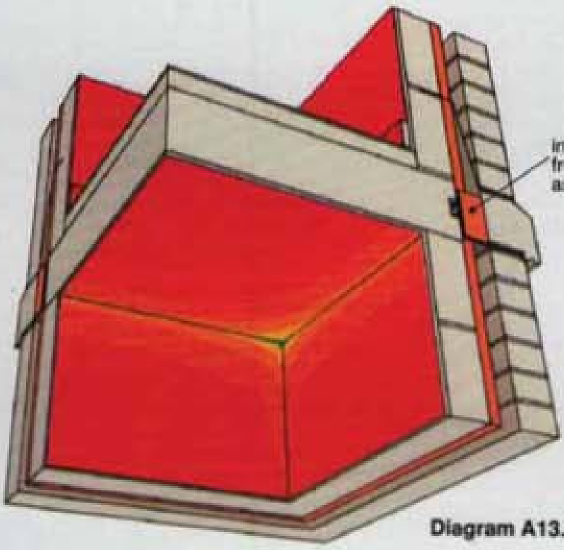


Diagram A13.2

SLIGHT RISK OF MOULD

Packing the void in front of the steel angle with insulation, as in Diagram **A13.2**, has virtually no effect. At first sight, this is an unexpected result. Analysis shows that the high proportion of steel angle that is on the cold side of the wall insulation, rapidly conducts and dissipates heat from the warmer, vertical section of the steel angle. This in turn, chills the adjoining concrete slab and blockwork. Placing insulation in front of the steel angle, as in Diagram **A13.2**, does not isolate the cold, highly conductive steel from the supporting concrete structure.

MINOR THERMAL BRIDGE

Using brackets to space the steel angle away from the concrete allows the cavity insulation to be continued behind the angle, as shown in Diagram **A13.3**. This results in substantially higher temperatures. It is assumed that steel support brackets are spaced at 500 mm centres.

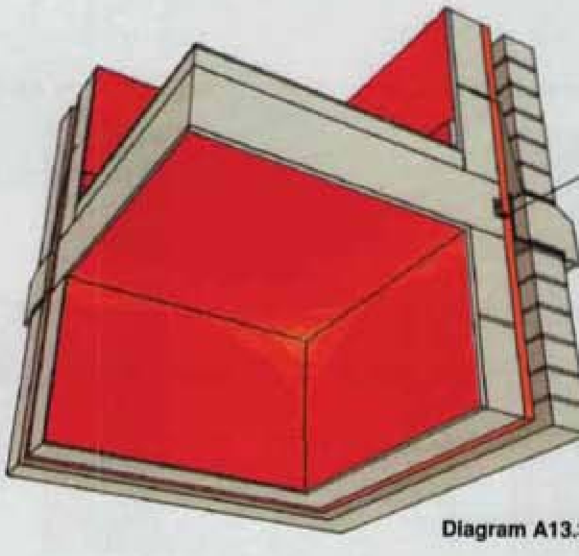


Diagram A13.3

B CAVITY INSULATED WALL – SELF SUPPORTING OUTER LEAF

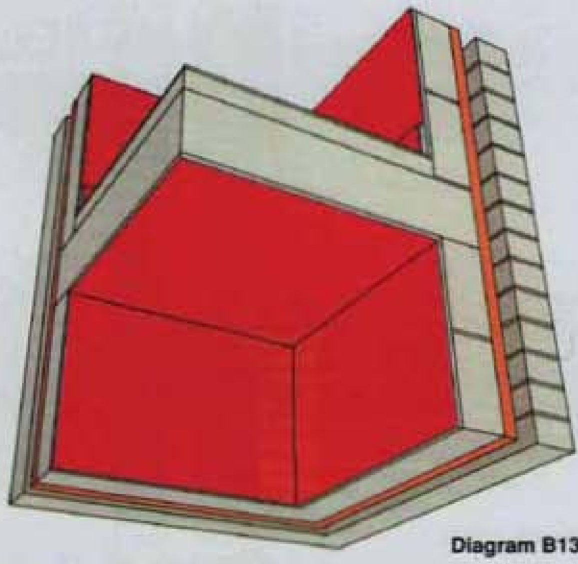


Diagram B13.1

BEST PRACTICE

The continuity of the cavity wall insulation ensures that there are no thermal breaks with this form of construction. The lower surface temperatures in the corner are due to the room geometry.

C INTERNALLY INSULATED WALL

MAJOR THERMAL BRIDGE

With internal wall insulation, a concrete intermediate floor will inevitably create a thermal bridge. The use of a false plasterboard ceiling, as shown in Diagram **C13.1**, is sufficient to raise surface temperatures at ceiling level to the point where the risk of mould growth is unlikely.

However, the surface temperature on the concrete floor slab within the ceiling void can fall as low as 7°C.

To minimise the risk of condensation on the concrete, it is strongly recommended that the plasterboard ceiling contains a vapour control layer that is continuous with the vapour control layer in the insulated wall lining.

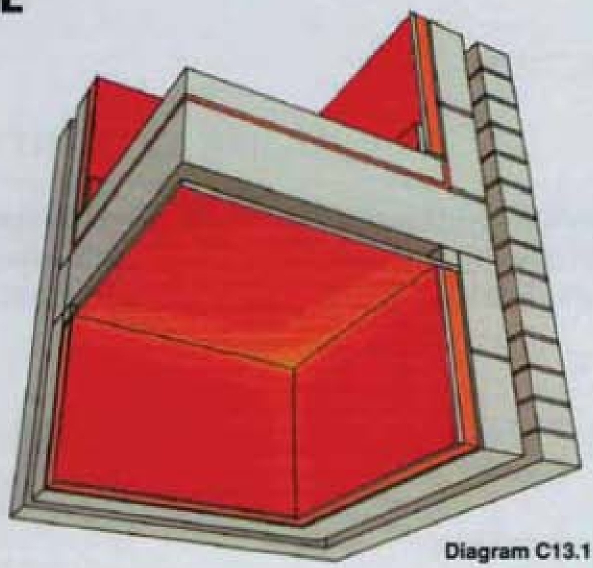


Diagram C13.1

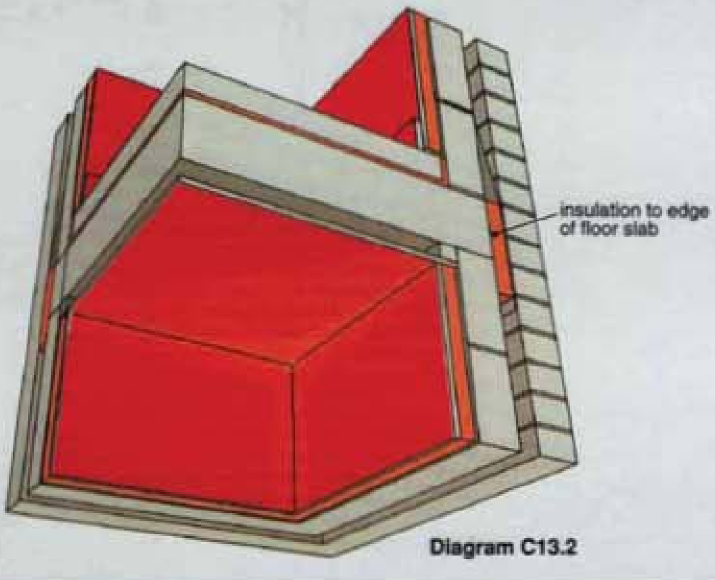


Diagram C13.2

MINOR THERMAL BRIDGE

Placing insulation in the wall cavity to insulate the edge of the floor slab, as in Diagram **C13.2**, helps to reduce the effect of the thermal bridge. Surface temperatures at the wall/ceiling junction are about 1°C higher. Although the underside of the concrete slab is about 2.5°C warmer, a vapour control layer in the ceiling is still recommended.

C INTERNALLY INSULATED WALL (continued)

CROSS-SECTION

Diagram **C13.2A** shows the temperatures through the construction, shown in Diagram **C13.2**, taken at the external corner.

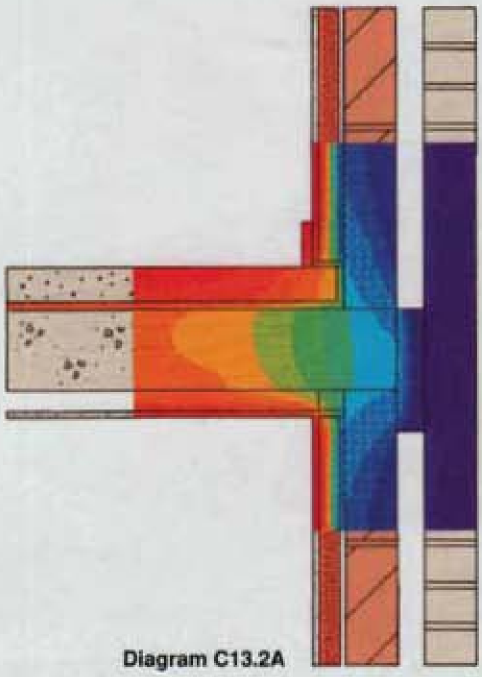
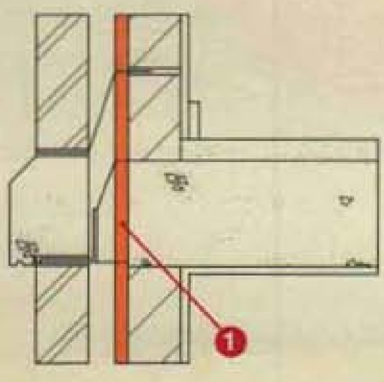


Diagram C13.2A

SUMMARY OF RECOMMENDATIONS

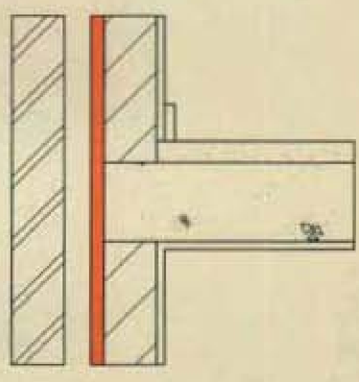
A Cavity insulated wall - angle supporting outer leaf



Minimum recommendations

1 Cavity insulation should be continuous behind the structural steel angle, interrupted only by the brackets needed to support the steel.

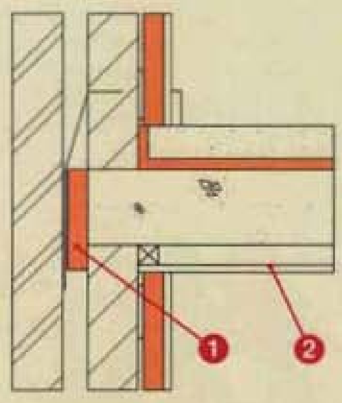
B Cavity insulated wall - self supporting outer leaf



Best Practice

The cavity wall insulation is continuous.

C Internally insulated wall



Minimum recommendations

1 Insulate the edge of the floor slab, AND

2 Specify a vapour control layer at ceiling level to minimise interstitial condensation on the underside of the slab.

Note: 'Minimum recommendations' provide advice on reducing the risk of mould growth occuring.

Concrete balconies

Introduction
Concrete upper floors that are extended through the external wall to form a balcony are a well known source of mould growth and condensation because of the thermal bridge.

The thermal analysis used in the preparation of this Guide uses steady state conditions and therefore does not take account of the cooling of the concrete floor slab between periods of intermittent heating. In the case of balconies, where the large thermal mass of the cantilevered concrete slab is directly exposed to the outside air, the cooling of the concrete once the heating has been turned off would result in the risk of mould growth being greater than under steady state conditions.

This points to the need for robust solutions. The best solution is to isolate the balcony slab from the main floor slab. However, such a solution raises the fundamental question, how the balcony slab is to be supported. Close cooperation is needed between the architect and structural engineer to find a suitable solution that is both structurally sound and also avoids a thermal bridge.

A CONCRETE BALCONY

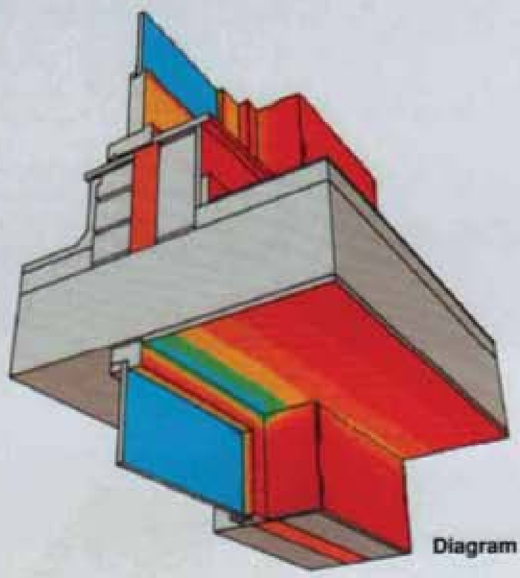


Diagram A14.1

MAJOR RISK OF MOULD

Diagram **A14.1** shows a classic thermal bridge where the concrete floor is continued through the external wall to form a balcony. There is a high risk of mould growth on the ceiling immediately behind the frame of the fanlight. However, the surface temperatures at the junction of the ceiling and the external cavity wall are high enough to avoid the risk of mould growth. The cavity insulation immediately above and below the concrete slab helps to keep the inner part of the concrete warm and restricts the rate at which heat is lost.

A CONCRETE BALCONY (continued)

MAJOR THERMAL BRIDGE

Diagram **A14.2** has ceiling insulation on each side of the frame. The ceiling insulation projects only about 100 mm into the room and a major thermal bridge exists.

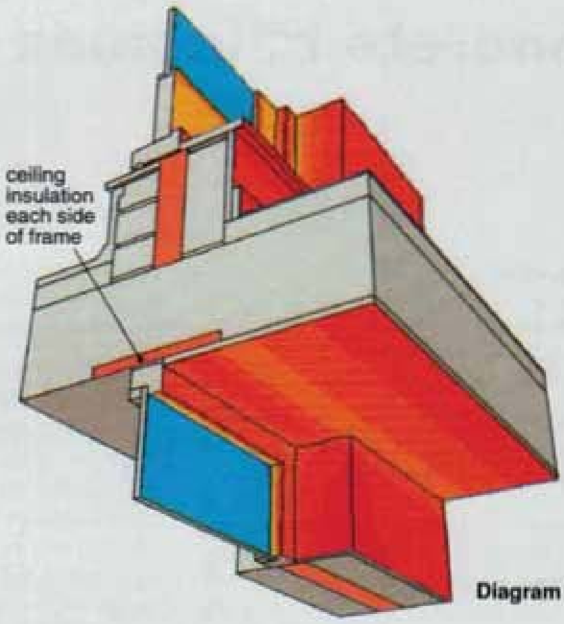


Diagram A14.2

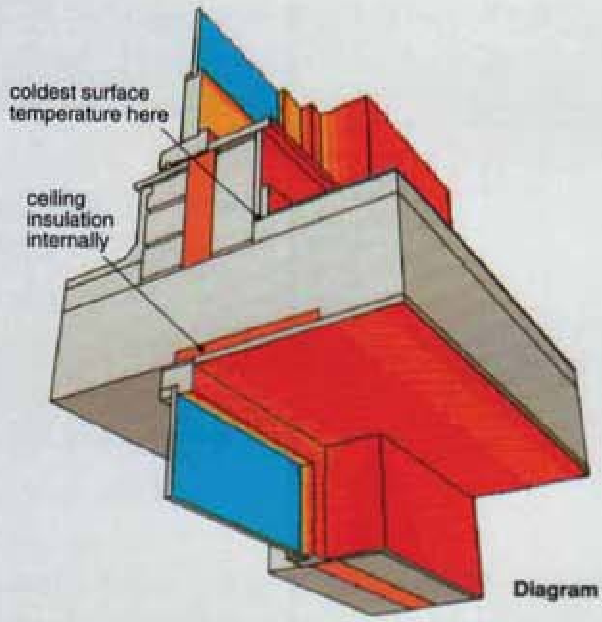


Diagram A14.3

MINOR THERMAL BRIDGE

Extending the insulation further into the room, as in Diagram **A14.3**, results in the coldest surface temperatures occurring on the floor, at the junction with the skirting board. Although ceiling temperatures are above 14.5°C under steady state conditions, the cooling of the slab overnight would increase the likelihood of surface condensation occurring.

BEST PRACTICE

Extending the cavity insulation through the slab, as in Diagram **A14.4** gives dramatically warmer surfaces. Cantilevered balconies have been designed using this detail by either maintaining continuity of the reinforcing steel between the floor and balcony slabs, or forming short stub beams between them. Alternatively, structural support to the balcony can be independent of the main structure.

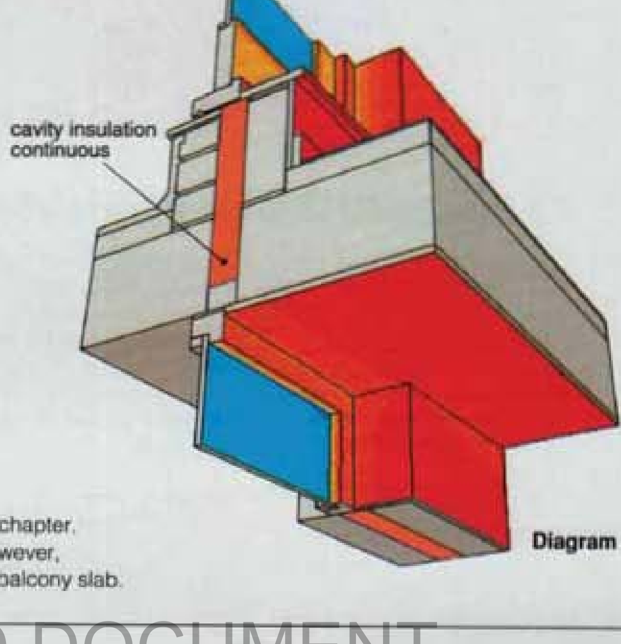


Diagram A14.4

Please note: There is no summary of recommendations with this chapter. The best solution analysed is shown in Diagram **A14.4** above. However, consideration needs to be given to the method of support for the balcony slab.

For further copies of this or other Best Practice programme publications please contact BRECSU and ETSU.
For buildings-related projects: Enquiries Bureau, BRECSU, Building Research Establishment, Garston, Watford, WD2 7JR. Tel 01923 664258. Fax 01923 664787. E-mail brecsuenq@bre.co.uk
For industrial projects: Energy Efficiency Enquiries Bureau, ETSU, Harwell, Oxfordshire OX11 0RA. Tel 01235 436747. Telex 83135. Fax 01235 433066.